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Knowledge, and the Creativity to Use It

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HI-MILL MANUFACTURING COMPANY
REMEDIAL INVESTIGATION/FEASIBILITY STUDY
HIGHLAND, MI

WORKPLAN

SITE SAFETY PLAN

QAPP

Prepared by:

**Techna Corporation
44808 Helm Street
Plymouth, Michigan 48170**

Revision No: 2

October 26, 1989



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**REMEDIAL INVESTIGATION/FEASIBILITY STUDY
HI-MILL MANUFACTURING COMPANY
HIGHLAND, MICHIGAN**

1.0 INTRODUCTION

Subsections 1.1 through 1.3.1 of this section reflect the opinions of Hi-Mill Manufacturing Company. The USEPA does not admit to the facts or conclusions contained in subsections 1.1 through 1.3.1. Attachments included in Appendix A of this workplan are for information only and are not hereby incorporated or made part of the consent agreement between Hi-Mill Manufacturing Company and the USEPA.

1.1 Purpose

This document contains the workplan for conducting a Remedial Investigation and Feasibility Study (RI/FS) at the Hi-Mill Manufacturing Company site in Highland Township, Michigan. This RI/FS program is designed in accordance with a Consent Agreement between the United States Environmental Protection Agency (USEPA), Region V, and the Hi-Mill Manufacturing Company (Hi-Mill). This work plan includes a site history, Remedial Investigation Sampling Plan, Feasibility Study Plan, Performance Schedule, Health and Safety Plan, Permitting Requirement Plan and Quality Assurance Project Plan (QAPP).

The objectives of the Hi-Mill RI/FS program are as follows:

- to conduct a Remedial Investigation (RI) of the site and other potentially impacted areas to determine the nature, extent and impact of potential hazardous substance releases to the environment;
- to conduct a feasibility study (FS) to determine the extent of appropriate remediation, if any, that is needed to prevent or mitigate the impact, migration, release or potential

release of hazardous substances from the site. The FS will also evaluate potential remedial alternatives to determine the one(s) most appropriate for the conditions and circumstances at the Hi-Mill site.

1.2 Project Description

The following subsections describe the location and plant operations history of Hi-Mill Manufacturing Company and the geology, hydrology and ecology of the plant site and surrounding areas. Summaries of previous contamination assessment and control activities, an overview of RI project tasks, intended data usage, and the RI project schedule are also presented.

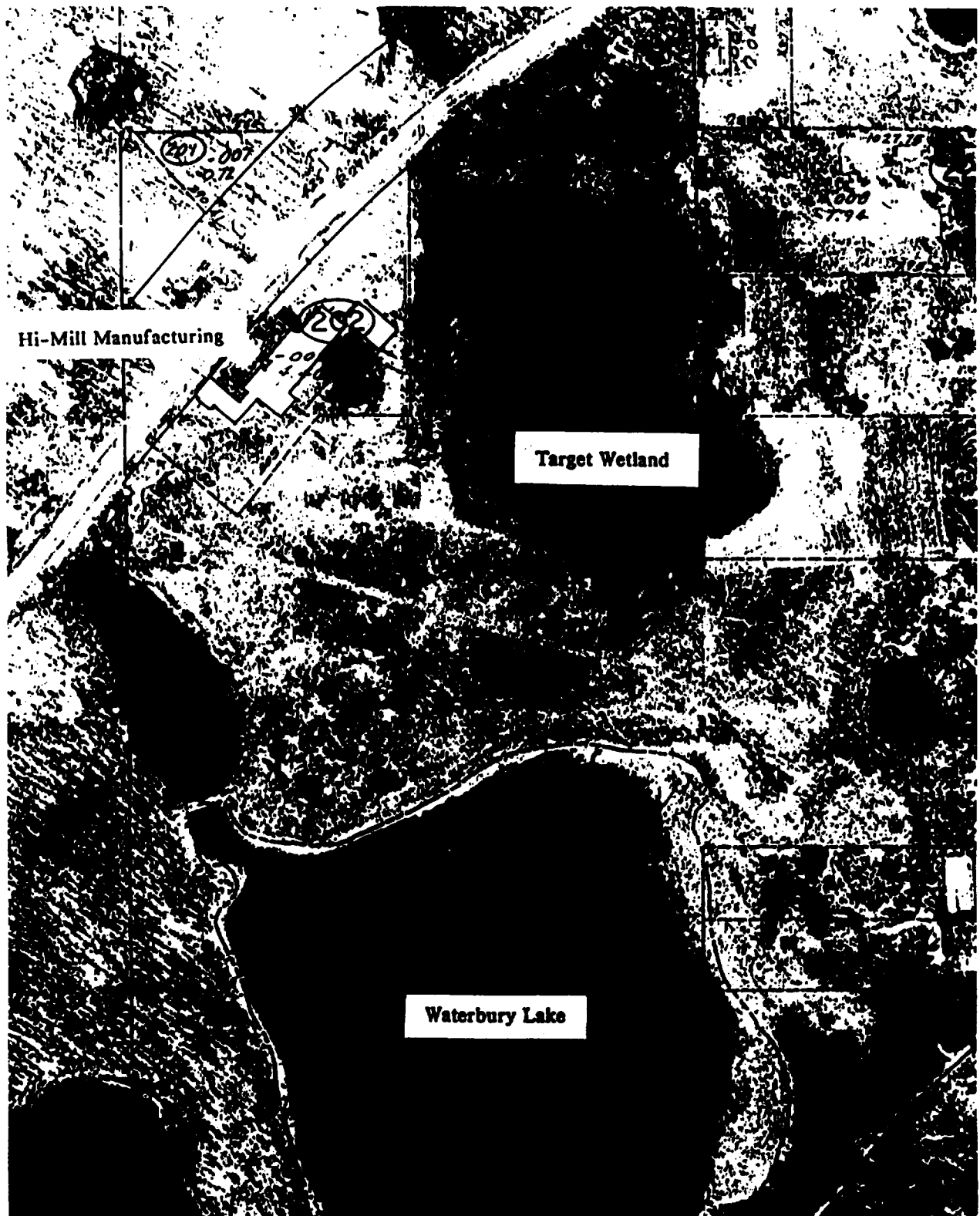
1.2.1 Location and Description

The Hi-Mill plant is located in southeastern Michigan in Highland Township, Oakland County, approximately 1.5 miles east of the town of Highland (Figure 1-1). The plant address is 1704 Highland Road (M-59) which is located within Section 23, T7N R18W. The site occupies an irregularly shaped property of approximately 4.5 acres in size (Figure 1-2) which lies at an elevation of approximately 1010 feet above mean sea level.

The Hi-Mill building and parking area occupy most of the site. The building lies in the northwest part of the property and is irregularly shaped, having been expanded several times since its original construction in 1946. It houses the corporate and administrative offices, tubing production facilities and raw material storage and preparation areas. Paved parking areas occupy all of the property northeast of the production/office building and part of the site southwest of the building. The remainder of the property is covered with vegetation.

The site is bounded to the northwest by Highland Road (M-59), a four lane, divided highway. It is bounded on all other sides by the Highland State Recreation Area, which is owned and maintained by the Michigan Department of Natural Resources. Specifically, the Hi-Mill site is bounded to the east by a marsh/pond of approximately 8 - 10 acres in size. The site is bounded to

FIGURE 1-2
1980 AERIAL PHOTO



the south by a slightly elevated, vegetated plain and woodlands area. Waterbury Lake lies approximately 900 - 1000 feet south of the site.

The immediate area around Hi-Mill is sparsely populated and rural in nature. The nearest dwellings lie approximately 2000 feet east and southeast of the site, along Waterbury Road. Numatics, Inc., a manufacturer of metal air control valve parts, is located approximately 1000 feet northeast of Hi-Mill at 2000 Highland Road East. Numatics discharges process wastewater to a drain tile field located on the property.

Highland Township is a rural/suburban area with a population of approximately 17,000 - 19,000. The rural/suburban nature of the township is reflected in the lack of large population or commercial centers and the absence of many city services. A majority of inhabitants obtain drinking water from domestic water wells and dispose of sewage through individual septic systems.

Hi-Mill Manufacturing obtains process and drinking water from two water wells located on the property (Figures 1-3 and 1-3A). One well, lying immediately west of the production building, is set at 50' below grade, and the other, lying immediately east of the production building is set at a depth of 89'. Sanitary sewage is disposed through a septic system.

1.2.2 Plant Operations History

Since its formation in 1946, Hi-Mill Manufacturing Company has fabricated copper, aluminum and brass tubing parts and fittings. Production operations have included cutting, machining, forming, shaping and soldering of the raw tubing and fabricated tubing components. Support operations have included nitric and sulfuric acid cleaning and pickling, chromic acid washing, and degreasing. All soldering operations have used silver solder or aluminum bar brazing; no tin-lead solder has been used in Hi-Mill's operations.

Aspects of Hi-Mill's historical plant operations which are pertinent to this RI/FS program are described below.

FIGURE 1-3
SITE PLAN

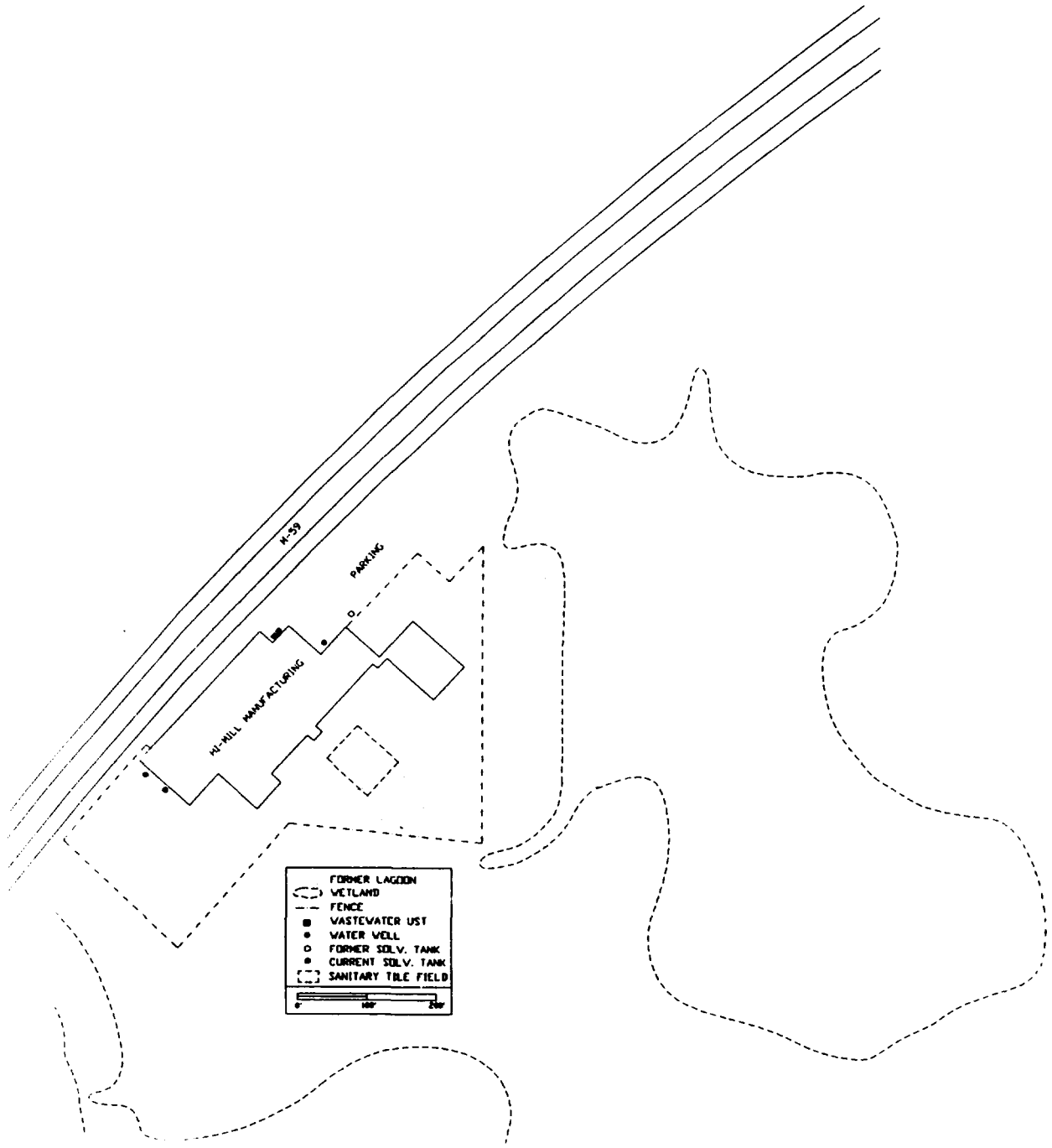
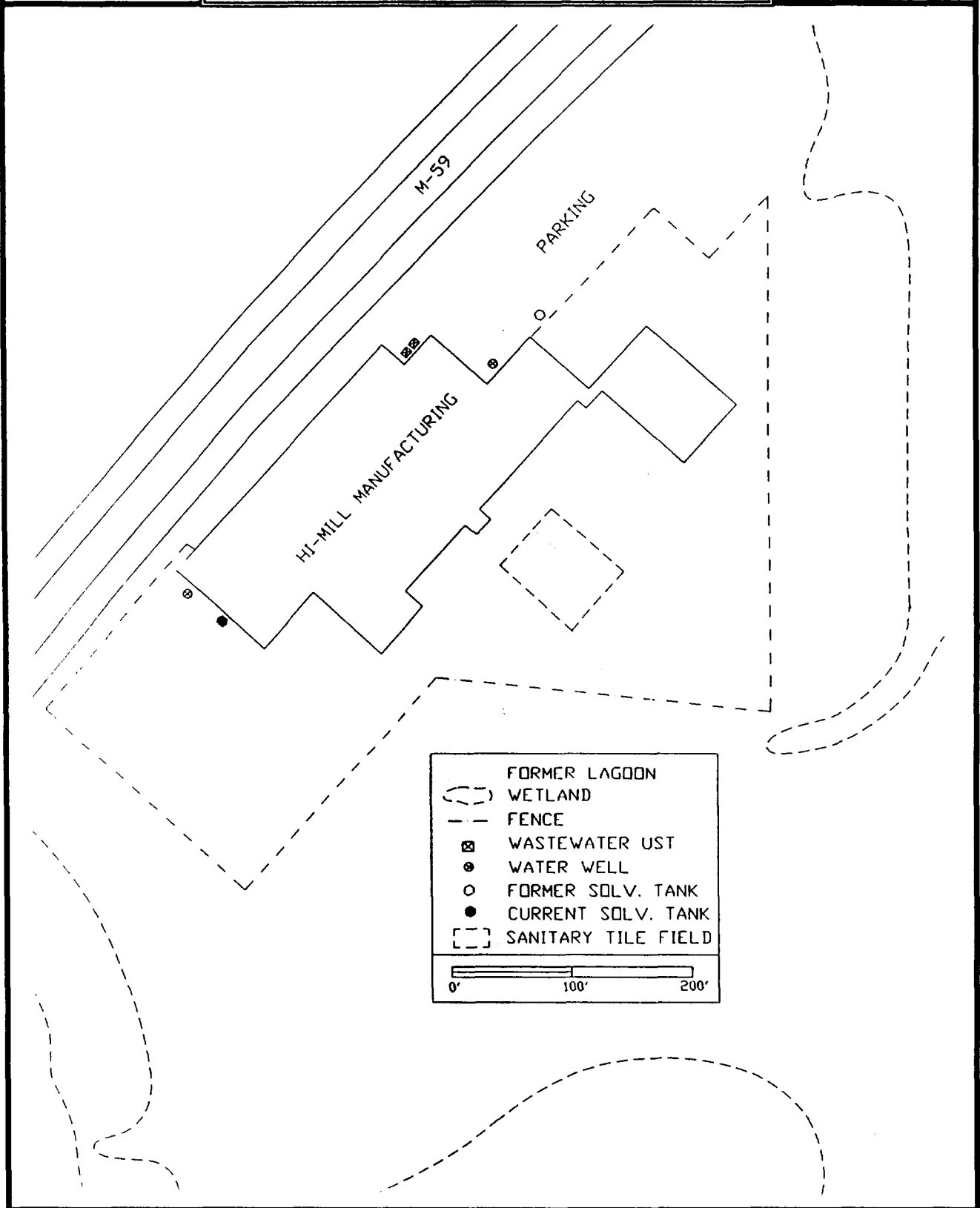


FIGURE 1-3A
ENLARGED SITE PLAN



Wastewater Discharges

From prior to 1960 (exact date unknown) to 1981 process wastewaters were discharged to an unlined lagoon located southeast of the main production building (Figures 1-3 and 1-3A). The lagoon was approximately 60 x 60 feet square, and the base of the lagoon was excavated approximately six feet into the underlying clay stratum. Based on results of subsurface stratigraphic investigations conducted in November 1988 (Appendix A), this stratum appears to be approximately 35 feet thick with some imbedded sand and gravel lenses. The sides and retaining walls of the lagoon were constructed of fill dirt and indigenous sandy clays.

Process waters consisting primarily of acid brightening solutions and acid brightening rinse waters were discharged to the lagoon. Reduction of water volumes in the lagoon occurred mainly through evaporation and seepage.

In 1975 Hi-Mill applied for and received a groundwater discharge permit (M00167, October 31, 1975) for the lagoon from the Water Quality Division of the Michigan Department of Natural Resources (MDNR). In the Fall of 1976, Hi-Mill constructed a second, smaller lagoon south of the original lagoon (Figure 1-3A). This second lagoon received overflow waters from the original lagoon.

In December 1976 and November 1977, direct overflows of the second lagoon to the nearby marsh were observed by MDNR staff. The company was then requested by the MDNR to apply for an NPDES permit for the discharges. A proposed permit was issued by the MDNR on September 16, 1977, but the USEPA refused to concur with the issuance of the permit. In December 1977 Hi-Mill agreed to design and implement a wastewater recycle system and cease discharging to the lagoons.

The wastewater recycle system was fully operational in 1981, and subsequent discharges to the lagoons were terminated. Between 1981 and 1983 Hi-Mill attempted to evaporate the water remaining in the lagoons by intermittently discharging it through spray nozzles attached to the roof of the production building and to portions of the eight-foot high fence that surrounds the rear (south) of the site.

All process wastewater that could not be recycled was pumped to an underground, concrete wastewater holding tank (Figure 1-3A) located in front of the northeast part of the production building. When this tank became full, the wastewater was transported by a licensed waste transporter to a permitted hazardous waste treatment facility. This waste management system is not now operative (Fall 1988) because Hi-Mill has terminated all production activities that produce metals-contaminated wastewater.

In September 1983 Hi-Mill requested permission from the MDNR to remove the sludge from the larger lagoon, excavate surrounding soils, and backfill the area with clean fill. This was accomplished in November and December 1983 by General Oil Company of Livonia, Michigan. Contaminated soils were removed from the sides and bottom of the large lagoon, and then an additional one foot of clay was excavated from the bottom of the lagoon to ensure removal of all contaminated soils. Excavated sludges and soils were transported and properly disposed off-site by landfilling in a properly permitted facility. All activities were monitored by representatives of the MDNR, and the excavated site was inspected by the MDNR prior to backfilling. The excavation contractor has indicated that the smaller lagoon was not apparent during the excavation; the fate of this impoundment is not known.

Degreasing Operations

Degreasing of fabricated tubular parts has been a part of Hi-Mill's process since prior to 1970. Trichloroethylene was received and stored in an aboveground tank located approximately 50' east of the production building and the east water well (Figure 1-3A). Solvent was transferred to the degreasing equipment inside the plant via underground piping. In 1986 a second trichloroethylene storage tank was constructed in a diked containment area (Figure 1-3A) immediately west of the production building and approximately 20' - 30' south of the west water well. In the Summer of 1988, the original, east tank and associated piping were removed and disposed.

1.2.3 Geology, Hydrology and Ecology

General Regional Geology

Surface topography and associated soil deposits in this region of Southeastern Michigan result from glacial processes occurring during the Wisconsin Glacial Stage of the Pleistocene Series. Glacial action has deposited a mantle of glacial debris (soil), ranging in thickness from 225 feet to more than 300 feet. The stratigraphy of the glacial deposit is quite complex and represents materials deposited during successive advancements and retreats of the ice front(s).

The surface topography of the region is generally representative of the interlobate morainic system which lies on a northeast-southwest axis extending from approximately Jackson to Oxford. This morainic system results from interaction of the Saginaw, Huron and Erie Lobes. The Saginaw lobe advanced from the northwest, joining the Huron Lobe which advanced from the northeast and the Erie Lobe which advanced from the east.

Surface formations within the study area were formed primarily during retreat of these glacial ice lobes with the subsequent meltwater influencing much of the topography and near-surface soil deposits. Much of the area contains outwash material at the surface, deposited by glacial meltwaters.

Many closed depressions (kettles) dot the outwash sediments. These formed as a result of large blocks of ice, left behind by the rapidly receding glacier front, which were surrounded and covered by outwash sediments. As the buried or partially buried ice blocks melted, the sediments slumped into the resultant voids. This phenomenon is responsible for the pitted outwash topography evident in the study area. Kettles serve as basins for the numerous lakes and swamps found throughout the region.

The subsurface stratigraphy in the region is complex and is representative of variable climatic conditions throughout the period of glaciation. Soils encountered within the profile may be well-sorted granular materials representative of a period of rapid melting, lacustrine clay indicating the presence of a lake near the ice margin, ground moraines indicating a period of ice advance, as well as buried recessional moraines. Therefore, throughout most of the area, the general stratigraphy of

the glacial deposits consists of regionally discontinuous interbedded layers of lacustrine clay, unsorted moraines and outwash deposits.

In general, the region can be characterized as having well defined surface moraines with moderate permeability, ground laid moraines and lacustrine clays with low permeability and outwash deposits ranging from moderate to high permeability. Where present, the finer grained soils serve as an aquiclude that provides a bottom seal for an unconfined surface aquifer. The clay aquicludes also serve as the top confining seal for some artesian aquifers within the general region.

Mississippian age Coldwater Shale underlies the glacial soil at estimated depths of 225 to approximately 300 feet.

Regional Groundwater

The thick, glacial drift (including outwash) coupled with the relatively impermeable (sometimes interbedded) till clay and underlying shale bedrock form a major groundwater reservoir. Surface deposits of sand and gravel outwash which are encountered throughout most of the area are very permeable. The morainic ridges are predominantly granular and moderately permeable with only a thin, discontinuous clay cap. The absorbent nature of the outwash and some morainic deposits is indicated by the lack of large scale water erosion and the rapid infiltration of precipitation falling upon them. The many lakes and swamps that dot the region are surface expressions of the water table. The entire area underlying this region is an excellent catchment basin and storage reservoir for groundwater.

In the immediate vicinity of the site, it appears that a relatively continuous zone of low permeability soil underlies the granular outwash encountered locally at the surface. This conclusion is based on the presence of clay soil within the most recent series of borings coupled with the presence of the well developed natural drainage feature leading from Waterbury Lake and the well defined channel occupied by Pettibone Creek.

A major groundwater divide roughly corresponding to the topographic watershed divide is located somewhat northwest of the site under consideration. The direction of regional groundwater

flow is nominally toward the southeast, and in the immediate vicinity of the subject site, local groundwater flow direction is also toward the southeast.

This region serves as the principal groundwater intake or recharge area for the buried sands and gravels of the glacial lake plain region located in parts of Royal Oak, Southfield, Troy, Avon, Bloomfield and Farmington Townships, in Oakland County.

Local Surface and Groundwater Conditions

The site is within a relatively complex surface outwash area which provided drainage from meltwaters originating in the vicinity of Duck and White Lakes to the north and northeast of the site as well as meltwater originating from Waterbury Lake and higher ground to the south. It is apparent that meltwater originating in the immediate vicinity of the Hi-Mill facility generally flowed northerly toward Alderman Lake and then southerly into Pettibone Creek. Development of the M-59 highway has altered the prehistoric surface water flows such that there is now very little south-to-north drainage of water across the highway right-of-way.

The Hi-Mill facility is bordered by M-59 and a horseshoe shaped wetland area which is partially occupied by Waterbury Lake (south of the facility). The wetland area is interrupted by a low ridge which separates the pond and wetland lying east of the facility from the larger wetland occupied by Waterbury Lake.

Based on the results of test borings performed in the area, it is apparent that the wetland area is a reflection of an unconfined surface aquifer residing in a relatively thin veneer of outwash soil. The underlying clay stratum disclosed in recent the borings (Section 1.1.4) may serve as a barrier between the superficial saturated zone and deeper, confined aquifers which have a different piezometric head (Section 1.1.4).

Based on available hydrogeological data, groundwater in the local surficial saturated zone appears to flow toward the wetland pond located south and east of Hi-Mill. The flow direction has been determined to be southeast at Hi-Mill and southwest at Numatics.

The surface and subsurface conditions observed at the site suggest that contaminants entering the western portion of the wetland zone east of Hi-Mill most likely would be predominantly isolated within that portion of the wetland. Based on historical and recent aerial photographs, there does not appear to be or have been any water course linking the area of investigation, including the wetland pond to be investigated, to Pettibone creek or other bodies of water lying north of M-59.

General Environment

The area surrounding the Hi-Mill facility is a valued habitat, much of which has been acquired by the Michigan Department of Natural Resources for inclusion in the Highland State Recreation Area. Due to the varied topography, including the presence of wetlands, the region provides important habitat for wildlife under increasing pressures from urbanization/development along the M-59 corridor.

The fishery resources in the area consist of warm water populations in the larger lakes and in Pettibone Creek. It appears unlikely that Waterbury Lake represents a particularly viable fishery resource, as it has a maximum depth of only approximately 5 feet. There is, however, no current information regarding and inventory of the lake's inhabitants. The pond located east of Hi-Mill is even less likely to be a viable fishery due to its low and variable water levels.

The majority of the land in the immediate vicinity of the site is un-managed with respect to vegetation. Where present (south of Waterbury Lake), abandoned farmland is reverting to a more natural state. The area supports a variety of plant species ranging from oak and maple stands on the forested upland areas to swamp forests, shrubby swamps of willow and dogwood and marshes containing cattails, reptiles, and bird species.

1.2.4 Previous Contamination Assessment and Control Activities

Seven contamination identification, assessment and/or control projects have been conducted at the Hi-Mill site to date. The activities and results of the projects are summarized below. Copies of reports discussed below are included in Appendix A.

Pre-1978 - MDNR Data

In April 1972 the MDNR staff investigated an employee complaint that the plant water wells might be contaminated. Samples of the groundwater from the two wells and surface water from the marsh were collected and analyzed. "Slightly elevated" (no comparison standard was presented) levels of copper (0.38 mg/l) were measured in one well, and elevated levels of copper and nitrates were measured in the marsh waters located immediately adjacent to the Hi-Mill property.

The MDNR collected additional samples of the marsh water on October 9, 1975. Analyses of these samples indicated elevated levels of copper, aluminum, zinc, chromium, and nitrates.

In May, November and December 1976, MDNR personnel collected and analyzed samples of the wastewaters contained in the two ponds. The mean concentrations of the parameters measured in these samples are presented below:

<u>Parameter</u>	<u>Concentration (mg/l)</u>
Copper	5.23
Aluminum	24.50
Chromium (total)	1.29
Chromium (hexavalent)	0.28
Nickel	0.02
pH	5.08
N (NH ₃)	13.67
N (NO ₂)	0.42
N (NO ₃)	59.67

Based on available data, there is no indication that background or QA/QC samples were collected or analyzed to validate the data collected in any of these early studies.

April 1978 - MDNR Study of Adjoining Marsh Area

In April 1976, staff of the MDNR Water Quality Division undertook a study of the soils and sediments in the marsh, water in the lagoon, and groundwater from one of Hi-Mill's water wells to

assess contamination potential. The well selected for sampling was the one identified in the 1972 study as having elevated levels of copper. Background sediment samples were collected from Pontiac Lake.

The chemical analysis results indicated no metals contamination in the Hi-Mill water well sample. Elevated levels of nitrate, nitrite, ammonia, copper, zinc and aluminum were measured in water samples from the lagoon and marsh waters immediately adjacent to the Hi-Mill property. Since no background samples were analyzed, it is not clear if results from a mid-marsh sample reflect normal or elevated levels of chemical species measured.

Elevated levels of total chromium, copper and aluminum were measured in sediment samples collected from the lagoon and marsh. Slightly elevated levels of lead and zinc were also reported. No nickel contamination was reported.

August 1982 - MDNR Hydrogeological Study

In August 1982 the MDNR Water Quality Division performed a hydrogeological study at the Hi-Mill plant site. This study consisted of the installation of six, shallow groundwater monitoring wells along the east and south property lines (adjacent to the Highland State Recreation Area), measurement of groundwater elevations, and sampling and analysis of groundwater samples. The monitoring wells were set at depths of 4' - 7' below grade in saturated surficial clayey soils of low permeability (MDNR conclusion based on soil type and well recharge time).

The flow of the perched water was determined to be generally in a southeasterly direction toward to marsh. Elevated levels (2 - 10 times background) of copper, chromium (total), zinc and aluminum were found in samples from monitoring wells located east and southeast of the lagoon. Concentrations of lead and nickel were found not to be above background levels.

November 1983 - Removal of Lagoons

In September 1983 Hi-Mill requested permission from the MDNR to remove the sludge from the large lagoon, excavate surrounding soils, and backfill the area with clean fill. This was

accomplished in November and December 1983 by General Oil Company of Livonia, Michigan. Contaminated soils were removed from the sides and bottom of the lagoon, and then an additional one foot of clay was excavated from the bottom of the lagoon to ensure removal of all contaminated soils. Excavated sludges and soils were transported and properly disposed off-site in a licensed landfill. All activities were monitored by representatives of the MDNR, and the excavated site was inspected by the MDNR prior to backfilling. The excavation contractor reported that the small lagoon observed in historical aerial photos was not in evidence at the time of excavation. The fate of the small lagoon is unknown.

April 1984 - MDNR Biological, Surface Water and Sediment Survey

In April 1984 personnel of the MDNR Surface Water Quality Division performed a limited biological, surface water and sediment survey of the marsh east of Hi-Mill, of Hi-Mill's roof and parking lot run-off areas and of the nearby Waterbury Lake. Water and sediment samples were collected and analyzed for aluminum, arsenic, iron, mercury, zinc, cadmium, chromium (total), copper, nickel and lead. Benthic and phytoplankton organisms were collected and identified visually on-site and by laboratory microscopy.

The chemical analyses of water samples indicated that concentrations of zinc, chromium and copper in marsh waters were lower than those measured in 1978, but still elevated in comparison to the background samples collected from Waterbury Lake. The levels of chromium and zinc did not exceed freshwater aquatic life criteria, but the levels of copper (50 - 200 $\mu\text{g/l}$) exceeded the chronic criteria (33 $\mu\text{g/l}$) for warm water fish. Elevated levels of copper, zinc, chromium and aluminum were also found in the run-off from the roof drainage and parking lot; the levels of copper in these samples exceeded the acute and chronic criteria for aquatic life.

Elevated levels (2 - 100 times those in sediments from Waterbury Lake) of aluminum, zinc, chromium (total), and copper were measured in sediments from the marsh and from parking lot and roof run-off drainage areas. Levels of arsenic, mercury, cadmium, nickel and lead were not found to be significantly different from the levels in Waterbury Lake samples.

The biological survey revealed few benthic or other bottom-dwelling organisms. Insufficient data were available to determine if this was a result of the significant marsh water level fluctuations or from metals contamination. Zooplankton were present at both sampling stations in the marsh. Daphnia sp., a copper sensitive organism, were abundant at the marsh sampling station where copper concentrations in the water were highest. The presence of a variety of filamentous green algae, flagellates, other algae and macrophytes indicated that the contamination did not have much impact on these aquatic plants.

The MDNR report noted that data collected during this survey supported the conclusion that "Waterbury Lake was not connected with the marsh east of Hi Mill Manufacturing and was not impacted by Hi Mill Manufacturing surface water discharges." This conclusion was further strengthened by the MDNR's choice of Waterbury Lake samples to represent "background". Additional samples will be collected from Waterbury Lake during the RI.

April - October 1987 - Numatics, Inc. Discharge Permit Data

Numatics, Inc. has been discharging wastewaters from metal finishing rinse tanks to a drain tile field under a MDNR groundwater discharge permit. In response to Numatics' most recent application to renew the discharge permit, the MDNR required a soils and groundwater assessment to determine if past discharge practices had negatively impacted the environment. The result of the soils investigation in the area of the drain field indicated that elevated levels of chromium and hexavalent chromium had accumulated in subsurface soils. Data from one round of samples from groundwater monitoring wells did not reveal significant levels of pollutants. The groundwater flow direction was determined to be southwest toward the wetland pond east and south of Hi-Mill.

March - November 1988 - Oakland County Health Department Process Well Survey

The Oakland County Health Department and the Michigan State Department of Health sampled and analyzed water samples from Hi-Mill's two production water wells seven times during the period March 22, 1988 through November 2, 1988. Initially, samples were analyzed for water quality parameters, trace metals and volatile solvents; later analyses were confined to volatile solvents. All samples were analyzed by the Michigan Department of Health laboratories in Lansing, Michigan.

No field or trip blanks were analyzed, and no laboratory quality assurance data is available to assess the validity of results.

All samples were found to contain "not detected" or acceptable levels of metals and other water quality parameters. The sample from March 1988 (composite of the two wells) was found to contain 41 $\mu\text{g/l}$ trihalomethanes and 1 $\mu\text{g/l}$ (method detection limit) benzene; the trihalomethanes have not been detected in subsequent samples and were probably sampling or analysis artifacts.

No volatile organics were measured in a June 29, 1988 composite sample.

On July 14, 1988, trichloroethylene was measured at 1 $\mu\text{g/l}$ (method detection limit) in the west well, and benzene was measured at 4 $\mu\text{g/l}$ in the east well; benzene has not been detected in subsequent samples and was probably a sampling or analysis artifact.

No organics were identified in a composite sample collected on September 1, 1988.

Another set of samples was collected on October 4, 1988; trichloroethylene was measured in both the east and west wells (3 $\mu\text{g/l}$ and 24 $\mu\text{g/l}$ respectively), and cis-1,2-dichloroethylene was measured (2 $\mu\text{g/l}$) in the west well.

Analyses of samples collected on October 12, 1988 indicated the presence of trichloroethylene and cis-1,2-dichloroethylene in the west well at levels of 3 $\mu\text{g/l}$ and 2 $\mu\text{g/l}$ respectively. Trichloroethylene was measured in the east well at 12 $\mu\text{g/l}$.

A sample collected from the west well on November 11, 1988 was found to contain 7 $\mu\text{g/l}$ trichloroethylene and 2 $\mu\text{g/l}$ cis-1,2-dichloroethylene. The sample from the east well was found to contain 3 $\mu\text{g/l}$ trichloroethylene.

The Michigan Department of Health notified Hi-Mill on November 7, 1988 that the analysis results indicated that the water from the process wells was not acceptable for human consumption. Hi-Mill was instructed to warn employees not to drink the water, to provide bottled drinking water, abandon both existing wells, and to install a new well to provide potable water to the facility.

November 1988 - Techna Corporation Hydrogeological Study

Techna designed and implemented a limited hydrogeological assessment of the Hi-Mill site in November 1988 in response to the findings of chlorinated solvents in the Hi-Mill process wells. A previous MDNR report indicated that the site is underlain by clay of low permeability. Well logs (non-MDNR) prepared by previous drinking water well installation contractors indicate that this layer is 25' - 45' thick. If this were true, the presence of chlorinated solvents in two wells, laterally separated by a distance of almost 300', would be difficult to explain based on typical soil migration mechanisms. Furthermore, the well screens are located at significantly different depths, 89' below grade for the east well and 50' below grade for the west well. This could imply that two different aquifers were affected.

Techna designed the hydrogeological program to accomplish the following objectives:

- determine subsurface stratigraphy to a depth of approximately 100';
- sample and analyze groundwater samples to determine extent of possible solvent contamination;
- determine approximate direction of groundwater flow in the deeper aquifer(s);
- evaluate connectivity between multiple, deeper saturated zones if any were found; and
- evaluate the potential for contaminants in surficial saturated zones near the process wells.

Three boreholes were advanced at the Hi-Mill site to an approximate depth of 100' below the existing ground surface. Boreholes were placed at the northeast corner of the property, at the west corner of the property, and south of the production building in the area of the former lagoon. Soil types were logged during the drilling operations, and temporary, 2" diameter PVC monitoring wells were placed in each location.

The general subsurface stratigraphy at the site consists of 1.5' - 3' of fill underlain by 26' - 45' of stiff, moist, silty blue clay. This layer was contiguous in the northeast and south borings; however, in the west boring a layer (5' \pm 2') of fine silty sand was found in the clay stratum between the depths of 12' and 17', and a compact sandy silt layer (3' \pm 1') was found between the depths of 24' and 27'.

In the northeast borehole, a wet sand stratum was encountered between the depths of 45' and 63'. This was underlain by a 21.5' thick layer of extremely stiff blue clay, which was in turn underlain by a wet layer of sand and gravel extending from 91' below ground level (BGL) to the terminus of the boring at 105.6'.

In the west borehole, the clay layer was underlain by various wet sand strata to a depth of 113' BGL, the terminus of the boring. The underlying sand strata were interspersed with layers of blue clay (64.5 - 66.5' BGL and 96.5 - 101' BGL) and extremely compact sand and silt (76' - 92' BGL).

The south boring initially encountered approximately 8' of sand fill resulting from removal of the former lagoon. This was underlain by the same clay stratum (26' thick) found in the other borings. The upper clay layer was underlain sequentially by compact to extremely compact wet sand (34' - 49.5' BGL), extremely stiff blue clay (49.5' - 59' BGL), wet gray sand (59' - 65.5' BGL), extremely stiff blue clay (65.5' - 87' BGL) and wet sand and gravel (87' - 100' BGL) to the end of the boring.

Temporary groundwater monitoring wells were then set in separate boreholes at the following locations:

- Northeast property corner - one screen was set at 55' BGL in the uppermost saturated zone, and one was set at 105' in the lower saturated zone;
- West property corner - one well was set at 56' BGL in the uppermost significant saturated zone;

- South of production building - one well was set at 50' BGL in the uppermost saturated zone , and one well was set at 93' BGL in the lower saturated zone.

The wells were fitted with 5' screens, and the bottom of the screens were placed at the depths listed above. After installation, the wells were developed and allowed to reach equilibrium.

Groundwater elevation measurements revealed that the static water levels in all wells were the same within an absolute variance interval of $\pm 0.6'$ about the mean elevation. This implies that the two deeper saturated zones are hydraulically connected. The groundwater was determined to be flowing in a generally southeast direction.

Groundwater samples were collected from each temporary monitoring well and analyzed for the Priority Pollutant volatile organic species. No contaminants were found in any of the samples. This implies that there is no wide spread contamination of the usable aquifers by chlorinated solvents.

Soil samples were collected in the surficial fill materials (found to be dry or slightly moist) near each process well and analyzed for the presence of chlorinated solvents. One sample was collected approximately 8' - 10' north of the east well, and one sample was collected approximately 8' -10' southwest of the west well. No chlorinated solvents were found in either sample.

The results of this study indicate that the 2' - 4' of surficial soils, and the surficial saturated zone contained therein, are underlain by a stiff clay layer which is probably sufficient to prevent to prevent hydraulic connection with the uppermost usable aquifers located at approximately 50' and 95' below ground level. This clay layer is also probably sufficient to prevent migration of solvent or metals contamination to the uppermost usable saturated zones. There does not appear to be a large contaminant (solvent) plume in the deeper saturated zones. The two deeper saturated zones are probably hydraulically connected to each other, but not to the surficial saturated zone.

The distance between the process wells, the low concentrations of chlorinated solvents, and the lack of solvent contamination in the surficial soils near the wells implies that the contamination discovered by the Oakland County Health Department is likely caused by migration of solvents from localized, surface spill(s) of trichloroethylene into the groundwater via the annulus surrounding the

wells. This conclusion is supported by the fact that solvent transfer and storage activities have been conducted near each well.

On instructions from the Michigan Department of Health, these two wells will be abandoned, and a new water source will be established on the site. The casings of the existing wells will be removed or destroyed in situ, and the entire borehole will be pressure sealed with grout. This action should stop any migration of contaminants via the suspected annulus route.

1.3 Remedial Investigation Overview

The following subsections describe the nature and extent of the problem at Hi-Mill, present an overview of the RI tasks, and summarized the site investigation boundary conditions.

1.3.1 Nature and Extent of the Problem

Currently available information about the Hi-Mill site indicates that environmental contamination may have resulted from past wastewater and chemical management practices. Preliminary data have revealed the potential for contamination of site soils, surficial groundwater, surface water and sediments in an adjoining marsh, and deeper aquifers. One off-site source, Numatics, inc., has been identified as a potential contributor of contaminants identified in previous investigations.

The results of studies performed by the MDNR indicate that wastewater seeping or overflowing from the former on-site lagoons may have contaminated the surficial groundwater, lying in the upper 4' - 6' of soil, with aluminum, chromium, copper and zinc. This groundwater is flowing in a southeasterly direction toward a nearby marsh/wetland. Contaminated groundwater may be present both on-site and off-site.

Analyses of surface waters and sediments in the adjoining marsh indicate that both media may have been contaminated by wastewater discharges or contaminated surficial groundwater from the Hi-Mill property. Aluminum, copper, chromium and zinc have been found at elevated levels

when compared with data from nearby lakes. A biological study of the marsh found a generally healthy ecosystem except for an absence of fish and bottom dwelling organisms. The study was inconclusive in determining if this absence was the result of variable water levels or chemical contamination. No data is currently available to allow a determination of the distribution of contaminants between the sediments and water.

There is currently no data to support an evaluation of the potential for contaminant migration beyond the marsh via the surficial groundwater or into deeper aquifers via recharge by surface water. Limited investigative and topographic data led to the MDNR staff's conclusion that Waterbury Lake, lying southwest of the site, had not been impacted by surface water discharges at Hi-Mill as of April 1984. However, additional samples will be collected from Waterbury Lake during the RI.

The presence of elevated concentrations of metals in the surficial groundwater and in the marsh may indicate that a residual contaminant source is present on the Hi-Mill site. Although contaminated soils and sludges were removed from the large lagoon in 1983, some contaminated soils and sludges associated with the smaller, overflow lagoon may still be present on the site. Other site soils may have been contaminated by the seepage from the lagoons or the spray evaporation procedure used intermittently in 1981 - 1983 to reduce the volume of water remaining in the lagoons after their usage was terminated. The Numatics, Inc. site located approximately 1000 feet northeast of Hi-Mill is the only other potential contaminant source known at this time.

Until the recent discovery of chlorinated solvents in groundwater samples collected from Hi-Mill's two production water wells, there was no indication that deeper aquifers were potentially affected by the company's wastewater or chemical management practices. Recent analyses of well water samples showed normal and acceptable levels of water quality parameters and metals. However, the presence of trichloroethylene and cis-1,2-dichloroethylene at concentrations of 1 - 24 $\mu\text{g/l}$ indicates a potential impact on the deeper, usable aquifers.

Recent subsurface stratigraphic, hydrogeological and sample analysis data indicates that the impact of these contaminants is likely to be slight and localized to the immediate vicinity of each well. The presence of a thick (26' -45'), stiff blue clay layer lying approximately 4' - 7' under the ground surface supports the hypothesis that migration of contaminants from near-surface sources

would be unlikely. The absence of chlorinated solvents in surficial soil samples collected near the wells implies that there is no large contaminant reservoir in the immediate vicinity of either well. The absence of chlorinated solvent contaminants in groundwater samples collected from the deeper aquifers implies that any contamination is localized. This conclusion is especially supported by the fact that no contaminants were observed in the samples collected from two saturated zones at a point south of the production building, downgradient from the production wells and immediately under the former lagoon.

The above data indicates that the chlorinated contaminants may likely be entering the aquifers via migration through the annuluses of the two wells. The sources of the contaminants are probably localized spills of solvent near the well heads. Trichloroethylene has been stored near both of the wells. The location and size of the contaminant source is unknown.

The scope of the RI will include examinations of potential site sources of aluminum, chromium, copper, nickel, silver, zinc and chlorinated solvents and the possible presence of these contaminants in surficial saturated zones and deeper aquifers. The RI will also collect data to evaluate the potential impact of contamination on the surface waters and sediments in the adjoining marsh. The possibility for migration of these metals from the marsh via surficial groundwater and via hydraulic connectivity with deeper aquifers will also be investigated. Atmospheric distribution of contaminants is not an issue in this program. Selected samples will also be analyzed for the TAL inorganics and TCL organics to examine the potential for contamination by other species.

1.3.2 Remedial Investigation Tasks

The Hi-Mill RI is designed to gather data to support identification of potential on-site sources of contaminants; determination of the levels and extent of contamination in surficial groundwater, deeper aquifers, and surface water and sediments in the adjoining marsh; determination of the existing and potential contaminant migration pathways between affected areas and media; and evaluation of the potential environmental and public health impact of any contamination. The results of the RI will be used to support a feasibility study into the available and most appropriate approaches for remedial action, if any is needed.

The RI strategy has been developed around the following three studies: 1) site soils, 2) on-site and off-site hydrogeology, and 3) marsh surface waters and sediments. Brief summaries of the technical approach and rationale for each of these studies are presented below.

Site Soils Study

The site soils study consists of two components. The first and largest is designed to evaluate all unpaved areas of the site to identify potential sources of metals contaminants. Exposed soils on and immediately surrounding the Hi-Mill property will be divided into 60' x 60' grid squares (Section 2.4, Figure 2-2). Surface and subsurface soil samples will be collected from each accessible grid intersection and analyzed for aluminum, copper, chromium, nickel, silver and zinc. Based on the compositions of materials (copper, brass and aluminum tubing) used in Hi-Mill's production activities and the results of previous investigations at the site (Appendix A), these are the contaminants which are reasonably expected to be present at elevated levels which could present an environmental risk. Selected samples will also be analyzed for the full lists of CLP TCL organic and TAL inorganic parameters to ensure that other contaminants are not present. Data from this study will provide a three dimensional profile of contaminant concentrations in the soils.

The second soils study will focus on potential trichloroethylene contamination of soils in the vicinity of the two process water wells. Soils in these two areas will be divided into 10' x 10' grid squares, and surface and subsurface samples will be collected from the center of each square. Samples will be analyzed for CLP TCL volatile organics.

Background soil samples will be collected from five different locations north and west of the study area. One of these samples will be collected from north of M-59.

Hydrogeological Study

The hydrogeological study is comprised of several components designed to attain the following objectives:

- confirm the groundwater flow direction and define and characterize the contaminant plume in surficial groundwater south and east of the site;
- determine the potential for migration of contaminants in surficial groundwater beyond the southern and eastern boundaries of the marsh;
- confirm the groundwater flow direction and potential for contamination of the two deeper aquifers located at approximately 50' and 85' below ground level;
- investigate the hypothesis that trichloroethylene contamination in the process wells is localized and not part of a larger contaminant plume; and
- determine the potential for contamination of the two deeper aquifers.

The technical approach and monitoring well locations are described in detail in Sections 2.5 - 2.7.

The surficial groundwater (4' - 7' BGL) in the vicinity of the site will be investigated by utilizing existing monitoring wells and installing additional ones. Wells will be installed to create two tiers of wells east of the site between the property boundary and the marsh and to two tiers of wells near the east portion of the south boundary. Two additional wells will be installed south of the production building in the vicinity of the two former lagoons, and another will be installed northeast of the production building near the underground wastewater storage tanks. Groundwater elevation data will be used to determine flow direction, and chemical analyses (copper, chromium, aluminum, nickel, silver and zinc) of groundwater samples will be used to define the extent of contamination. Selected samples will also be analyzed for CLP TCL organic and TAL inorganic species to determine if additional contaminants are present. Based on the compositions of materials (copper, brass and aluminum tubing) used in Hi-Mill's production activities and the results of previous investigations at the site (Appendix A), the metal analytes listed above are the contaminants which are reasonably expected to be present at elevated levels which could present an environmental risk. Selected samples will also be analyzed for ammonia and nitrate/nitrite to assist in determining overall groundwater quality.

Additional monitoring wells will be installed in the surficial saturated zone (4' - 8' BGL) around the south and east sides of the marsh. Groundwater samples from these wells will be analyzed for copper, chromium, aluminum, nickel, silver and zinc to determine if these contaminants have migrated south of the site or beyond the marsh. Groundwater elevation data will be used in flow direction determinations.

The potential for contamination of the uppermost usable aquifer will be determined by sampling and analysis of samples from the saturated zone lying approximately 50' below ground level. Monitoring wells will be installed in the uppermost usable aquifer in five locations to determine groundwater flow direction and potential for contamination by copper, chromium, aluminum, nickel, silver, zinc and TCL volatile organics. TAL inorganics will be analyzed in samples from three of these wells. Wells will be installed in the northeast corner of the property (upgradient of the site), southeast (downgradient) of the west process well, south of the production building (southeast and downgradient of the east process well), south of the property boundary and north of M-59 as shown in Figure 2-3. These locations were selected to determine if contaminants from the plant property or the wetland have entered the target aquifer.

Groundwater elevation data will be used for determination of groundwater flow direction. Samples from each well will be analyzed to determine if the aquifer is contaminated. Analysis data from the two wells located downgradient from the process wells will be used to evaluate the hypothesis that the recently discovered solvent contamination is localized and not part of a larger plume. Boring log data will be used to complete the mapping of subsurface stratigraphy. Hydraulic connectivity between the 1) marsh pond and 2) surficial saturated zones and the uppermost usable aquifer will be inferred from the presence or absence of target contaminants in the latter. Slug tests will be performed to determine permeability of soils in the saturated zone.

Three monitoring wells will be installed into the saturated zone located approximately 85' - 100' below ground level. These wells will be installed southeast (downgradient) of the west process well, south of the production building (southeast and downgradient of the east process well), and south of the property boundary. Samples from these wells will be analyzed for aluminum, chromium, copper, nickel, silver, zinc and the TCL volatile organic parameters.

Surface Waters and Sediments

Samples of surface waters and sediments from the marsh will be collected from the locations described in Section 2.8 and Figures 2-5 and 2-6 and will be analyzed for copper, chromium, aluminum, silver, nickel and zinc to evaluate the levels and distribution of contaminants. Based on the compositions of materials (copper, brass and aluminum tubing) used in Hi-Mill's production activities and the results of previous investigations at the site (Appendix A), these are the contaminants which are reasonably expected to be present at elevated levels which could present an environmental risk. Three sediment and water samples will be analyzed for the TAL inorganic parameters to ensure that other contaminants are not present in the wetland area.

Most sampling locations will be in the approximate areas where samples were previously collected by the MDNR to provide a level of data comparability. Two sample locations were selected in the drainage area leading from the Numatics property, lying east of Hi-Mill, to the wetland to investigate the potential for contaminant contribution from the Numatics property.

Sediment samples will be collected from ten stations in the wetland, two stations in Waterbury Lake and one station north of M-59 in an area which may receive water from the wetland during times of high water. Water samples will be collected from eight of these stations. Background samples will be collected from a wetland, of the same classification as the marsh, located approximately 1000' southwest of Waterbury Lake. Four water and four sediment samples will be collected from evenly distributed locations in the background wetland.

1.3.3 Site Investigation Boundary Conditions

The necessity for this remedial investigation is based predominately on evidence that wastewater management practices at Hi-Mill Manufacturing have resulted in environmental contamination of surficial groundwater, surface water and sediments in the Highland State Recreational Area. The majority of investigative work in this RI will be conducted within the boundaries of the Hi-Mill property (Figure 1-3) and surrounding areas of the Highland State Recreational Area. The area of investigation in the recreation area will extend south and west to

Waterbury Lake and east to the eastern boundary of the marsh/wetland. Limited activities will be conducted north of M-59 and in a wetland located approximately 1000' southeast of the site.

Collection of background samples will involve access to highway rights of way located north of the wetland, private or state property located north of Highland Road, and a wetland located in the recreational area southeast of Waterbury Lake.

This RI/FS program has been designed on the basis of currently available information to provide the data necessary to characterize the types and extents of contamination at the site and to support development of any remedial action that may be deemed necessary. However as with all such investigations, data collected during the investigation may reveal other data gaps or the need to pursue additional sampling and analysis programs to fully characterize the site. If the results of the investigation indicate that additional contaminants are present at environmentally significant levels or that contaminants from Hi-Mill activities have migrated into the uppermost usable aquifer or beyond the investigated area, the remedial investigation may be subject to modification pursuant to the consent order. If the RI scope is expanded at the conclusion of the program described herein, an amended workplan will be developed and submitted to the RPM.

2.0 REMEDIAL INVESTIGATION SAMPLING PLAN

2.1 Introduction

The Hi-Mill RI is designed to gather data to support identification of potential on-site sources of contaminants; determination of the levels and extent of contamination in surficial groundwater, deeper aquifers, and surface water and sediments in the adjoining marsh; determination of the existing and potential contaminant migration pathways between affected areas and media; and evaluation of the potential environmental and public health impact of any contamination. The results of the RI will be used to support a feasibility study into the available and most appropriate approaches for remedial action, if any is needed.

This Sampling Plan and the accompanying Site Safety Plan were prepared to provide a detailed description of field activities proposed for the Hi-Mill Manufacturing facility site. The purpose and methodology of each proposed task is outlined as well as a description of the sampling parameters and health and safety considerations. The field activities at the Hi-Mill Manufacturing Facility site will include the following tasks:

- Establish a soil sampling grid system,
- Surface and sub-surface soil sampling,
- Monitoring well installation,
- Groundwater sampling,
- Determination of aquifer potentiometric surfaces, and
- Surface water and sediment sampling.

The data obtained from the sampling tasks will be assessed initially to determine the magnitude and extent of any contamination problem that may exist as a result of past chemical and/or wastewater management activities on-site. An Endangerment Assessment and Feasibility Study will be prepared.

2.2 Map Existing Surface Topography

Presently, the only available topographic map of the site is a Highland Quadrangle, Michigan - Oakland County, 7.5 minute series USGS map. Aspects of this investigation, such as the surface soil sampling and the determination of aquifer potentiometric surfaces require an up-to-date,

detailed survey and accurate topographic data to successfully complete the task. Therefore, a detailed site topographic map will be prepared.

Abrams Aerial Survey Company of Lansing, Michigan has been subcontracted to perform a ground-truthed aerial photographic survey of the Hi-Mill Manufacturing Facility site and the surrounding areas included in the RI. This photographic survey will provide the information necessary to construct a topographic map of the study area with a scale of one inch (1") equals fifty feet (50') with a two foot (2') contour interval. This map will provide more detailed, up-to-date information about the site than is presently available. The results of the photographic survey will also be used to locate the major site landmarks. These include the site boundaries, fences, roads, drainage ditches, tile fields, wetlands, lakes, buildings and vegetated areas.

The surface soil sampling program is based upon ten foot (10') by ten foot (10') and sixty foot (60') by sixty foot (60') grid patterns to be superimposed across various portions of the site. An engineering/surveying company will be subcontracted to locate baselines across the site which will be used for the construction of the grid. The subcontracted surveyor will also perform a benchmark survey referenced to United States Geological Survey (USGS) mean sea level (msl) datum. Horizontal and vertical surveys shall be recoverable to within zero point five feet (0.5') and zero point zero two feet (0.02'), respectively.

Techna personnel will perform the necessary site inspection and background search to locate all surface and subsurface utilities. Utilities will be shown on the site map along with the data source, type of service, size, invert elevations and materials.

All survey notes and calculations will be written in serialized field notebooks dedicated to this project. All survey data will be maintained and secured in accordance with the Quality Assurance Project Plan (QAPP).

2.3 Site Operations Preparation

A temporary office and secure storage area will be established on-site (within a portion of the existing facility) at the location shown in Figure 2-1. The office and storage area will be used for the following:

- An on-site operations office in which all necessary paper work can be performed;

- A storage area where sampling and monitoring equipment, operation manuals, and other materials relating to site operations may be securely stored;
- To receive and send communications by telephone; and
- To log in and out all equipment and personnel involved with the RI.

An area will also be prepared at the location shown in Figure 2-1 for decontamination of all equipment and for storage of potentially contaminated materials. Fifty-five (55) gallon drums (DOT approved) will be supplied with plastic liners and covers and placed in the decontamination area to be used for storage of potentially contaminated materials. A decontamination pad will be constructed as a 20-mil PVC lined area, ten feet (10') feet wide by thirty feet (30') feet long, underlain by a one foot thick sand cushion. The liner and sand cushion will have a zero point five foot (0.5) foot high edge to prevent spillage of decontamination liquids. The decontamination pad will be sloped such that gravity drainage will be to a collection sump. Accumulated decontaminated fluids will be pumped to drums for storage prior to analysis and disposal. All potentially contaminated liquids and solids will be contained on-site until proper disposal methods are determined.

2.4 Soil Sampling

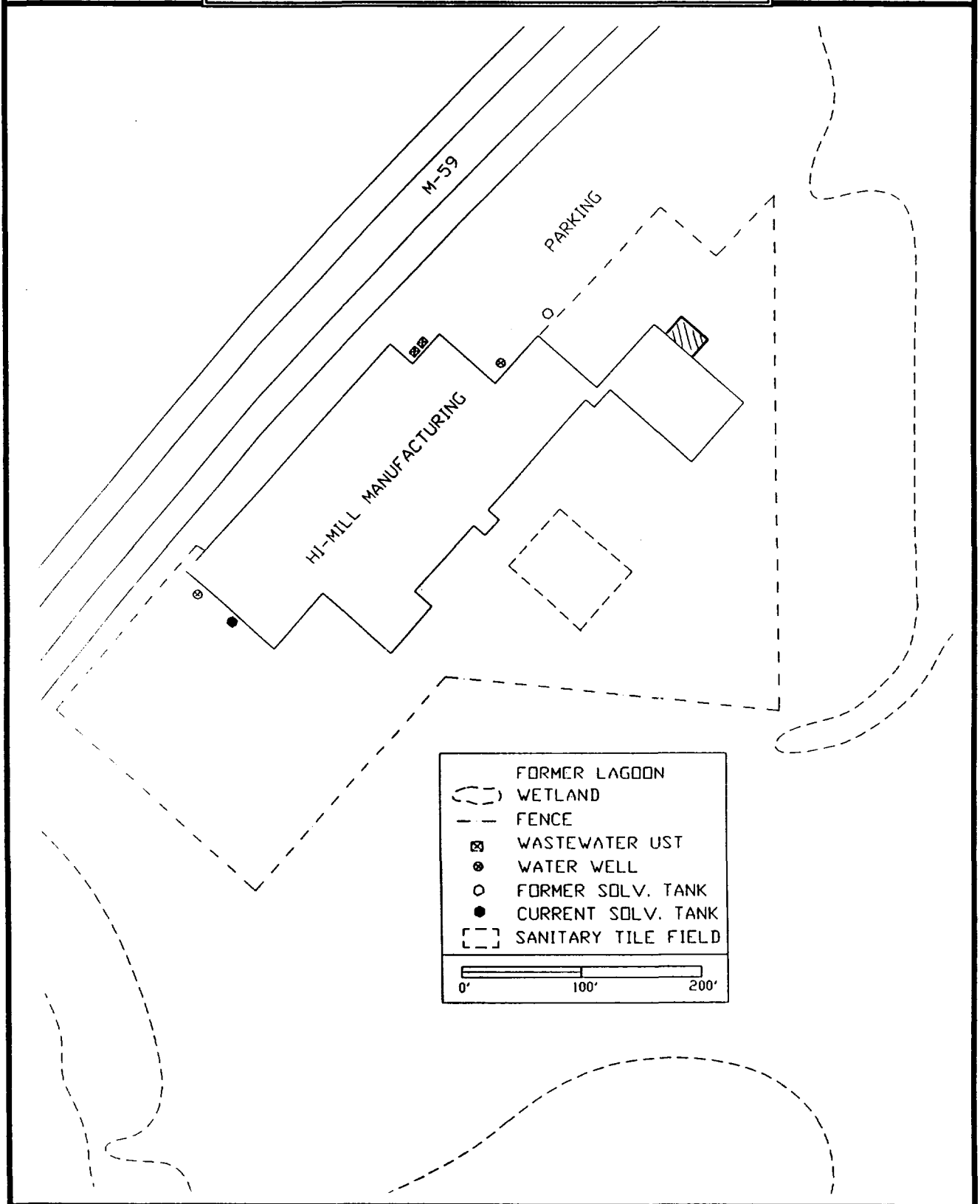
2.4.1 Strategy

The purpose of sampling and analyzing surface and subsurface soils is to establish if they are potential groundwater contaminant sources. Due to prior chemical and wastewater management activities conducted at this site, a potential exists for surface and subsurface soil contamination. Initial sampling activities are designed to fully characterize the surface and subsurface soils at the site through unbiased patterned sampling, as well as to focus on areas of suspected potential contamination through directed sample collection activities.

The surface and subsurface soil sampling program will be conducted on an established grid in each of the following areas:

- **Location 1)** - the west production water well where surface trichloroethylene contamination is suspected: ten foot (10') by ten foot (10') sample grid;

FIGURE 2-1
SITE DIAGRAM



- **Location 2)** - the northeast production water well where surface trichloroethylene contamination is suspected: ten foot (10') by ten foot (10') sample grid;
- **Location 3)** - the entire southern portion the facility (south of the existing facility structure), where a large area of contamination resulting from air borne contaminants from wastewater evaporation activities and seepage of wastewater from the abandoned lagoons is suspected: sixty foot (60') by sixty foot (60') sample grid. This sample grid will provide for collection of samples within, under and around the sanitary wastewater tile field and the areas of the former lagoons.

The smaller grid sizes were selected for sampling locations where the areal extent of contamination is expected to be small and the exact location is important to the evaluation of the production well contaminant source. The larger grid size was selected for the bulk of the property because the goal of this sampling is to determine if any large sources of residual contamination remain on the property; if such sources are discovered, additional sampling on smaller grids may be necessary to determine precise limits of contamination.

Surface and subsurface soil samples will be collected from the gridded areas and analyzed for aluminum, copper, chromium, silver, nickel and zinc. Based on the compositions of materials (copper, brass and aluminum tubing) used in Hi-Mill's production activities and the results of previous investigations at the site (Appendix A), these are the contaminants which are reasonably expected to be present at elevated levels which could present an environmental risk. Selected samples will also be analyzed for the full lists of CLP TCL organic and TAL inorganic parameters to evaluate the potential for contamination by other species.

Data from this study will provide a three dimensional profile of contaminant concentrations in the soils above and at the interface of the uppermost confining clay layer. Since migration of contaminants at the site will have occurred via dissolution in groundwater, this RI is primarily directed toward evaluation of the soils above the confining clay layer (aquiclude). Soils from the upper 2'- 3' of the clay stratum will also be evaluated to determine the potential for migration of contaminants into the clay. The locations and sampling points are identified in Figure 2-2. Table 2-1 summarizes the soil sampling and analyses program.

Analysis of background soil samples collected from points outside the grid pattern in areas believed to be free from impacts of site activities and, thus, potential contamination, will form the basis for evaluation of the levels of constituents in other samples.

FIGURE 2-2

SOIL SAMPLING DIAGRAM

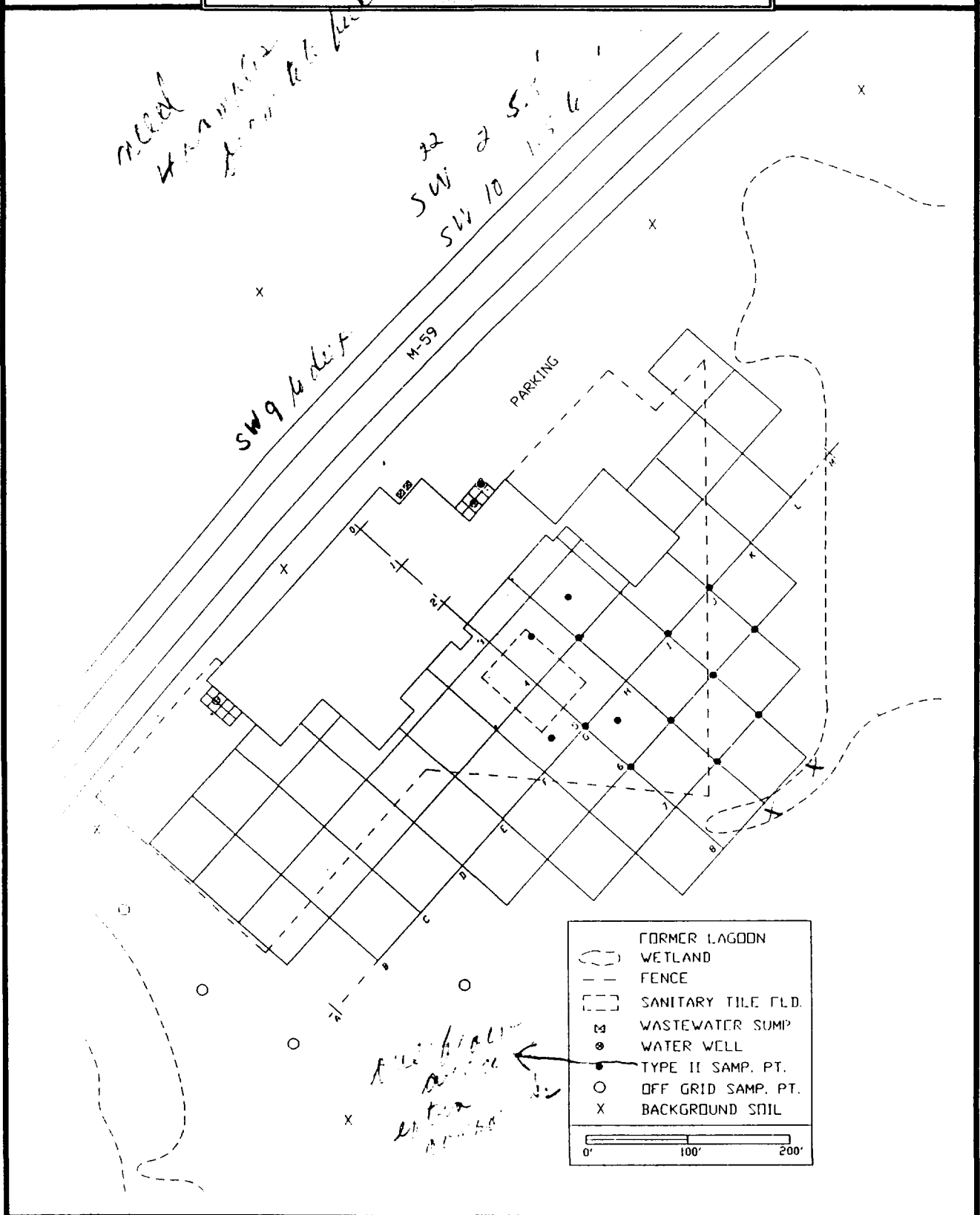


TABLE 2-1
SUMMARY OF SAMPLING PROGRAM

<u>Sample Type/Matrix</u>	<u>Field Measurements</u>	<u>Laboratory Parameters</u>	<u>Number of Samples</u>	<u>Field Duplicates</u>	<u>Field Blanks</u>	<u>Matrix Total</u>	<u>Trip Blanks</u>
Surface/Subsurface Soils		TAL Al, Cr Cu, Ni, Ag & Zn	179	18		197	
		TAL Inorganics	28	3		31	
		TCL Volatiles	76	8		84	
		TCL B/N/A	13	2		15	
		TCL Pest./PCB	13	2		15	
		Grain size	9	1		10	
		Atterberg limits	9	1		10	
		Hydraulic Cond.	14	2		16	
		Moisture content	9	1		10	
Groundwater (Phase I)		TAL Al, Cr Cu, Ni, Ag & Zn	23	3	3	29	
		TAL Inorganics	6	1	1	8	
		TCL Volatiles	19	2	2	23	1/shipment cooler
		TCL B/N/A	3	1	1	5	
		TCL Pest./PCB	3	1	1	5	
		NH ₃ , NO ₃ /NO ₂	21	3	3	27	
	pH, Temp., Sp.Cond.		29	3		32	

TABLE 2-1 (Cont.)
SUMMARY OF SAMPLING PROGRAM

<u>Sample Type/Matrix</u>	<u>Field Measurements</u>	<u>Laboratory Parameters</u>	<u>Number of Samples</u>	<u>Field Duplicates</u>	<u>Field Blanks</u>	<u>Matrix Total</u>	<u>Trip Blanks</u>
Groundwater (Phase II)		TAL Al, Cr Cu, Ni, Ag & Zn	23	3	3	29	
		TAL Inorganics	6	1	1	8	
		TCL Volatiles	19	2	2	23	1/shipment cooler
		TCL B/N/A	3	1	1	5	
		TCL Pest./PCB	3	1	1	5	
		NH ₃ , NO ₃ /NO ₂	21	3	3	27	
	pH, Temp., Sp.Cond.		29	3		32	
Surface Water		TAL Al, Cr Cu, Ni, Ag & Zn	10	1	1	12	
		TAL Inorganics	4	1	1	6	
		Cr+6	14	2	2	18	
		NH ₃ , NO ₃ /NO ₂	3	1	1	5	
Sediment		TAL Al, Cr Cu, Ni, Ag & Zn	18	2		20	
		TAL Inorganics	4	1		5	
		Cr+6	22	3		25	

2.4.2 Establishment of Sampling Grid

In order to establish reference points from which data generated from the surface and subsurface soil sampling activities may be correlated, grid systems will be developed in the study area and will be parallel to the long axis of the production building. These grid systems will ensure that all measurements made during the investigation can be located and presented in graphic form.

An engineering/surveying company will survey in perpendicular base lines across the site. Intervals of sixty feet (60') will be marked with metal stakes. Upon completion of the baselines, Techna personnel will expand the grid system in both directions across the site, southeast of the production building (Figure 2-2). Techna personnel will reduce the sixty foot (60') grid system to a ten foot (10') grid system in the area of the facility production wells. Intervals of sixty feet (60') will be marked with survey flags and each survey flag will be marked with the appropriate location identification code. Northwest-southeast lines will be labeled numerically and southwest-northeast lines will be labeled alphabetically.

2.4.3 Collection and Analysis of Samples at Locations 1 and 2

Samples will be collected from the center of each 10'x10' grid square located southwest and northeast of the production building as shown in Figure 2-2 during the advancement of soil borings using a hollow stem auger. If cracks or breaks are present in the pavement in a grid square, the boring location will be moved from the center of the grid to the area of the fissure. The exact locations of borings will be approved by the USEPA site coordinator.

Four soil samples will be collected from each of the 16 borings. These samples will be collected from the following depths below grade: 0-6", 2-2.5', at the interface of any clay layer identified or at the interface of any perched water identified, and 2.5'-3' below the previous interface. Sixty three (63) soil samples will be analyzed for aluminum, chromium, copper, nickel, silver and zinc and the TCL volatile organics. One (1) soil sample collected from the interface depth in the northeast grid area will also be analyzed for the TCL organics and the TAL inorganics. This sample will be selected based on field observations and will be approved by the USEPA site coordinator.

2.4.4 Collection and Analysis of Samples from Location 3

The following types of sample collection areas are included in Location 3:

- Grid intersections inside the boundary fence (including the tile field area),
- Grid intersections outside the boundary fence,
- Special (Type II) sample points in areas of highest suspected contamination, and
- Non-grid sample areas in small, eroded drainage channels southwest of the boundary fence.

These sampling areas are indicated in Figure 2-2.

Samples from twenty four (24) grid intersections within the fence (except for Type II locations) will be collected from 0-6" below existing grade and at the surficial soil-clay interface. These forty eight (48) samples will be analyzed for aluminum, chromium, copper, nickel, silver and zinc.

Twenty eight (28) samples from grid intersections outside the fence will be collected from 0-6" below the existing ground surface. Twenty four (24) of these samples will also be analyzed for aluminum, chromium, copper, nickel, silver and zinc. The four (4) samples from grid locations C-4, E-5, G-7 and L-4 will be analyzed for the TAL inorganics.

Three (3) samples will be collected at each of the three Type II sample points located in the area of the former large lagoon from the following three (3) depths: half-way into the overlying fill soils, at the fill-clay interface, and 3-4' below the interface. The interface sample (1) from location H-4 will be analyzed for the TCL organics and TAL inorganics. The interface samples (2) from the other two borings will be analyzed for the TAL inorganics. The other six (6) samples from these three locations will be analyzed for aluminum, chromium, copper, nickel, silver and zinc.

A total of forty four (44) samples from the other eleven (11) Type II locations will be collected at the following four depths: 0-6", 2.5-3', at the clay interface, and 2.5-3' below the interface. Exact locations for off-grid sampling will be approved by the USEPA site coordinator. The six (6) interface samples from borings in the former small lagoon and from I-6, I-7 and J-6 will be analyzed for the TAL inorganics. The other thirty eight (38) samples will be analyzed for aluminum, chromium, copper, nickel, silver and zinc. The interface sample from G-5 in the former small lagoon will also be analyzed for the TCL organics.

One sample from each of the four small drainage channels southwest of the property boundary will be collected from 0-6" below the existing ground surface. These four (4) samples will

be analyzed for the TAL inorganics. Exact locations will be approved by the USEPA site coordinator.

2.4.5 Sample Collection Methodology

The locations of sampling points are identified in Figure 2-2. A description of the number of samples and sample analytes for each sample location is presented in Sections 2.4.3 and 2.4.4. Table 2-1 summarizes the soil sampling and analysis program. Soil samples will be collected from within a one foot (1') radius of the survey flag which marks the grid line intersection being sampled. Every attempt will be made to sample from all proposed sampling points; however, access to grid squares and obstructions within grid squares may ultimately determine which grid squares are to be sampled. It is the objective of this task to determine the areal extent of soil contamination.

Samples will be collected through existing paving in Locations 1 and 2, but only from areas of exposed soils in Location 3. If the entire surface in any grid square in Location 3 is covered with an impervious surface, no samples will be collected. Where possible, samples will be collected with trowels or hand augers. Elsewhere, samples will be collected during the advancement of soils borings using a continuous flight, hollow stemmed auger drilling technique. Based upon available information obtained in previous investigations (Section 1), which indicates surficial sands and fills underlain by relatively impervious clay soils, it is estimated that these borings will be extended approximately three feet (3') to eleven feet (11') below the existing ground surface.

The surface and subsurface soil sampling entails the completion of approximately fifty-five (55) soil borings and 32 surface soil samplings in the following locations:

- **Location 1)** - Eight (8) borings adjacent to the west production water well.
- **Location 2)** - Eight (8) borings adjacent to the northeast production water well.
- **Location 3)** - Approximately thirty nine (39) borings and 32 surface soil samples located south of the existing facility.

Proposed sampling locations were selected to provide the maximum information possible about the study area. Location 1, was selected to determine if the contaminants detected in the west production water well are the result of surface spills of trichloroethylene solvent. Location 2, was selected to determine if the contaminants detected in the northeast production water well are the

result of surface spills of trichloroethylene. Location 3 was selected because it may have received air borne contaminants from prior waste water evaporation activities and/or may have been affected by leachate seepage from the abandoned lagoons.

Surface soil samples will be collected using a stainless steel trowel or hand auger. Samples from soil borings will be collected using two inch (2") diameter, two foot (2') long split spoon samplers. Each sample will be collected by advancing the split spoon sampler through and ahead of four and one-quarter inch (4 1/4") inside diameter continuous flight, hollow-stem augers. The hollow-stem auger drilling will proceed with an AW rod and bite plug attachment to prevent any heaving of soils inside the augers. Samples will be obtained in advance of the hollow stem augers. Samples will be collected from the upper 6" of soil at the existing ground surface and at two foot (2') intervals thereafter by means of a split spoon sampler until underlying confining clay soils have been penetrated to a depth of at least two feet (2'). The last sample will be collected from the terminus of the borehole. A standard one hundred forty pound (140#) drop hammer will be used to drive the split spoon sampler, and blow counts will be recorded for each six inches (6") of drive.

Modified Level D protection as defined in the Health And Safety Plan will be used during the work associated with sampling and handling of the surface and subsurface soils. A photoionization detector will be used for continuous ambient air monitoring of volatile organics during all drilling operations. A combustible gas indicator will be used for continuous ambient air monitoring of combustible gases during all drilling operations. If organic vapors are measured in excess of five (5) ppm above background, the protective wear will be upgraded to the appropriate level established in the Health And Safety Plan. If combustible gases are measured in excess of twenty percent (20%) LEL, all drilling activities will be suspended until gases have dissipated.

The waste soils and auger cuttings will be retained on four (4) mil polyethylene sheeting as drilling proceeds. Upon completion of each boring, the auger cuttings will be placed in steel drums and will be moved to the site waste storage area for characterization prior to proper disposal. The borehole will be backfilled with bentonite grout.

Each borehole will be filled with cement-bentonite grout upon completion of sample collection activities. Each sample point will be staked and labeled upon completion, and a survey will be performed to establish the location and elevation.

The drilling crew will consist of two (2) trained persons from McDowell & Associates. The sample handling and data entry will be performed by two (2) qualified personnel from Techna.

Prior to sampling at each location, all drilling equipment and/or applicable sampling tools will be steamed cleaned. The stainless steel trowels and the split spoon samplers will be decontaminated using the following procedure: trisodium phosphate (TSP) wash, tap water rinse, ten percent (10%) nitric acid rinse, distilled water rinse and complete air dry. When samples are being collected for organic parameter analyses, the sampling equipment will also be rinsed with laboratory grade methanol prior to the final distilled water rinse. Following decontamination procedures, the split spoon samplers will be wrapped in aluminum foil and stored until usage in the field.

Upon retrieval of each split spoon sampler, the sample will be extruded onto clean aluminum foil. Upon extrusion of each split spoon sampler, the following sample collection procedures will be used:

- 1) A visual description of the split spoon sample will be entered in the field log noting such features as color, grain size, sorting, roundness, structure, composition, and obvious presence of contamination such as discoloration and/or odor.
- 2) A portion of the sample will be retained for visual record, and the sample will be given an identification number. VOA samples will then be filled with soils obtained from the entire length of the core sample; VOA vials will be completely filled with sample to minimize headspace as much as possible. All soil samples collected for analysis of metals and non-volatile organic parameters will then be thoroughly homogenized so that no visual discontinuity is apparent. All cobbles or other large pieces of material (such as twigs or small sticks) will be excluded from the samples. The homogenized mixture will be randomly quartered, and portions will be selected for analysis. Before leaving the sample location, all pertinent data regarding the samples will be entered into the field notebook. A decontaminated stainless steel trowel will be used to divide the sample.
- 3) In the area of sample Locations 1 & 2, two (2) sets of two (2) laboratory-prepared VOA bottles (four (4) ounce glass jars), or jars purchased from I-Chem, will be filled with samples obtained from the sampling points. The VOA bottles will be placed on ice in a cooler and transported to the analysis laboratory. Samples will be submitted for TCL volatiles analysis. The purpose of two sets of the samples is to assure that duplicates will be available for any desired sample if additional material is desired by the laboratory. Samples will be collected from one location for TAL inorganics and TCL organics.

- 4) In the area of sample Locations 3, laboratory-prepared, eight (8) ounce glass jars, or jars purchased from I-Chem, will be filled with samples obtained from the sampling points. Samples will be submitted for analysis of aluminum, chromium, copper, nickel, silver and zinc.

Twenty four (24) selected samples will also be collected and prepared (as per step 3) for analysis of the full list of CLP TAL inorganic parameters and three samples will be prepared for TCL organics analyses to ensure that other contaminants are not present. These samples will be collected as described above from areas having the highest probability of contamination by past wastewater management practices.

QA/QC samples for these tasks consist of field duplicates. The duplicates will receive 1) TAL Al, Cr, Cu, Ag, Ni & Zn, and/or 2) TCL Volatiles, and/or 3) TCL organics and/or 4) TAL inorganics and/or ammonia, nitrate/nitrite analysis as appropriate (see Table 2-1).

Duplicate samples will be collected by splitting each trowel of soil in half and placing half of the soil in one sample bottle and the other half in the duplicate sample bottle. The duplicate samples will be given false sample identifiers, while the actual sample identifiers will be recorded in the field log book. Duplicate samples are intended to monitor laboratory methodology consistency.

Table 2-1 summarizes the field and laboratory sampling network for soil samples at the Hi-Mill Manufacturing Facility site. Table 2-2 presents the type of sample bottles, preservatives, and holding times for all samples collected during this task.

Once sample collection has been completed at each grid point, the sample bottles will be filled with soil and labeled with a date and unique identification code which will indicate the type and location of samples. All laboratory samples will be identified using an alphanumeric system. Each sample identification will have a lettered prefix which designates the sample type. The prefixes used for Hi-Mill Manufacturing (HM) site will be HMW for water and HMS for soil and sediment. This prefix will be followed by a designation for the sample location. This designation will be the well number for groundwater samples (e.g. -IW3), the grid location and sample depth for grid soil samples (e.g. -E5-2), the symbol TP, BP or WL and sequential sample point designator (and depth designator for sediments) for samples from the proximate wetland pond, background wetland pond and Waterbury Lake, respectively, and associated drainage areas (e.g. -TP1 or -TP1-1 as appropriate), and the symbol OG and a sequential sample point designator for soil samples from off-grid locations (e.g. -OG1). Field duplicates will be identified by the suffix -D appended to the sample number.

Table 2-2
Sample Containers and Preservatives

<u>Parameter</u>	<u>Container</u>	<u>Preservation</u>	<u>Holding Time</u>
<u>Soil/Sediments Samples</u>			
Volatile Organics	Glass Vials (2-120 ml)	Cool 4°C	10 Days
Metals	Wide Mouth Glass (1-8 oz; 3/4 full)	Cool 4°C	180 Days Except Mercury 26 Days
Hexavalent Chromium	Wide Mouth Glass (1-4 oz; 3/4 full)	Cool 4°C	24 hours for Extract Analysis
Semivolatiles and Pesticide/PCB	Wide Mouth Glass (1-8 oz; 3/4 full)	Cool 4°C	10 Days Extraction 40 Days Analysis
Cyanide	Wide Mouth Glass (1-8 oz; 3/4 full)	Cool 4°C	12 Days
<u>Well Water/Surface Water Samples</u>			
<u>Parameter</u>	<u>Container</u>	<u>Preservation</u>	<u>Holding Time</u>
Volatile Organics	Glass Vial with Teflon Septum (2-40 ml) Full-No Headspace	1:1 HCL, pH<2 Cool 4°C	10 Days
Metals (A)	Polyethylene (1-1 Liter)	HNO ₃ , pH<2	180 Days Except Mercury - 26 Days
Hexavalent Chromium	Polyethylene (1-0.5 Liter)	Cool 4°C	24 hours
Semivolatiles (BNA)	Amber Glass (1-2 Liter)	Cool 4°C	5 Days Extraction 40 Days Analysis
Pesticide/PCB	Amber Glass (1-2 Liter)	Cool 4°C	5 Days Extraction 40 Days Analysis
Cyanide	Polyethylene (1-1 Liter)	0.6 gr Ascorbic Acid NaOH, pH>12 Cool 4°C	12 Days

(A) A 0.45 Micron filter will be used to field filter each water sample for analysis

Note: Holding times are from date of receipt by Laboratory

Examples of the application of the sample numbering system are presented below:

- HMS-E5-2 = soil sample from grid point E5 at 2' depth;
- HMW-IW3 = groundwater sample from monitoring well IW3;
- HMW-TP5 = surface water sample from target pond, sample location #5;
- HMS-TP5-2 = sediment sample from 2' depth at target pond sample location #5;
- HMS-OG1 = surface soil sample from off-grid location #1;
- HMS-OG1-D = field duplicate of above sample.

Each sample container will be labeled with the following information:

- a. Project name and number,
- b. Sample ID number,
- c. Date and time of sample collection,
- d. Names and signature of sampling personnel,
- e. Special remarks (if any), and
- f. Analysis parameters.

The soil samples will be stored on ice at four degree Celsius (4°C) until analyses are performed. Chain-of-custody forms will be completed. Samples will be properly packed and shipped by courier in a sealed cooler to ENCOTEC in Ann Arbor, Michigan for analyses. The sample documentation, identification and chain-of-custody procedures are outlined in the Quality Assurance Project Plan (QAPP).

2.4.6 Background Soil Sampling

Background surface soil samples will be collected from the five (5) locations shown in Figure 2-2. These samples will be collected from within a one foot (1') radius of the survey flag which marks the sample locations (Figure 2-2). Every attempt will be made to sample from all proposed sampling points, however, access to locations due to obstructions will ultimately determine the exact sample points, subject to USEPA and MDNR approval. These samples, from points near the area of investigation, but outside the grid pattern, are from multiple areas believed to be free from disturbances and, thus, potential contamination. All sample points will be selected so as to avoid soil areas that are subject to frequent flooding by precipitation run-off. The southern-most sample point will be placed atop the ridge lying southwest of the facility.

Samples will be collected from each background sample point during the advancement of soil borings using the continuous flight, hollow stem auger technique described above. One sample will be collected from each soil horizon which correlates to soil horizons encountered during the sampling of Locations 1, 2 and 3. Equipment decontamination, sample collection and auger cutting management techniques will be as described above. An estimated ten (10) samples will be collected, of from each of two (2) soil horizons estimated in each boring. All ten (10) samples will be analyzed for the TAL inorganics and TCL organics.

2.5 Groundwater Monitoring Well Installation

2.5.1 Purpose

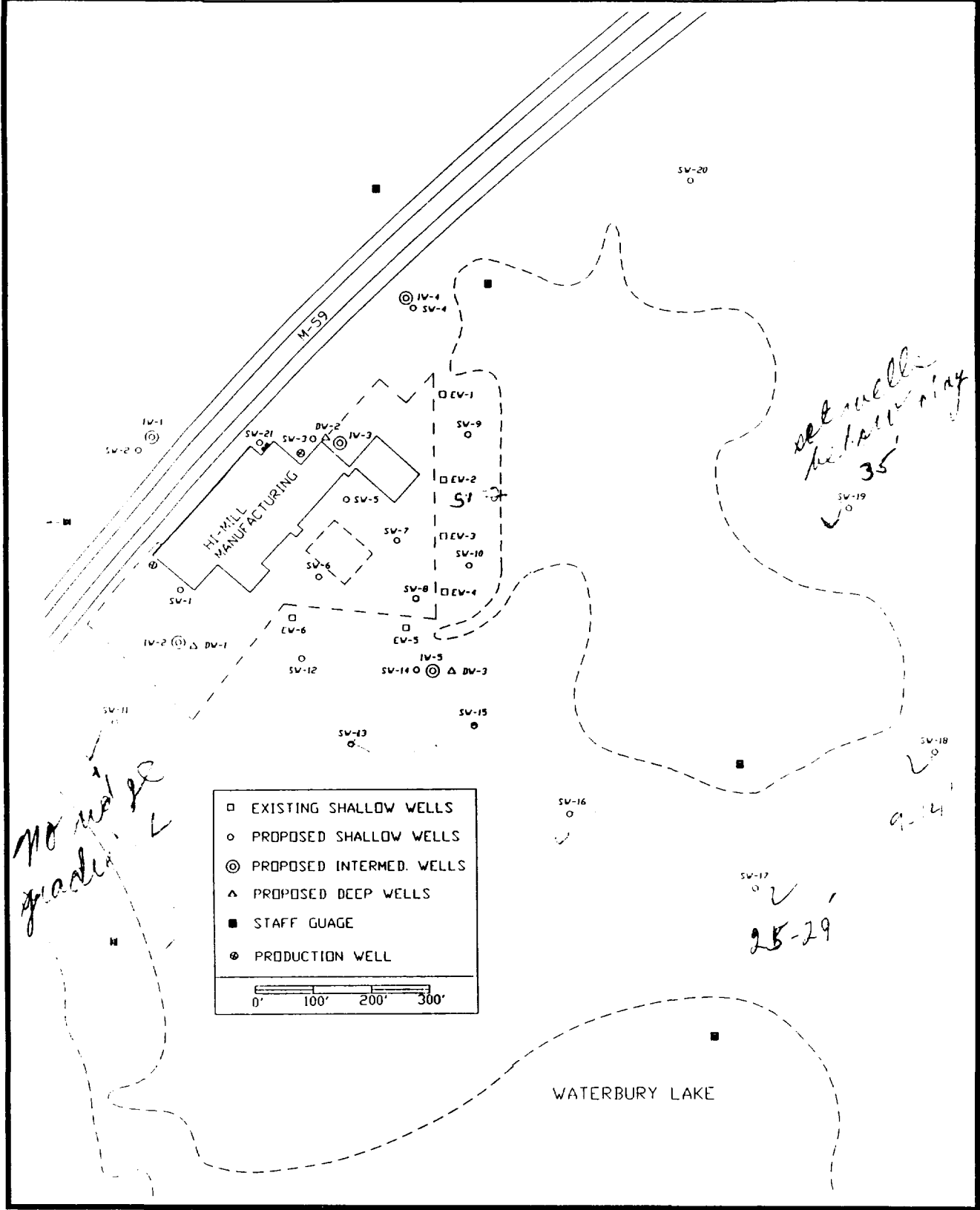
The subsurface hydrogeological conditions at the Hi-Mill Manufacturing Facility site are not clearly defined. Preliminary data have revealed the potential for contamination of site soils, surficial groundwater, surface water and sediments in an adjoining marsh, and one or two deeper aquifers. Recently discovered data indicates that a potential off-site source (Numatics, Inc.) of contamination lies northeast of the site.

Based on the results of test borings performed in the area, it is apparent that the wetland area is a reflection of an unconfined surface aquifer residing in a relatively thin veneer of outwash soil. The underlying clay stratum (disclosed in the borings) may serve as a barrier between the upper aquifer and a deeper, confined aquifer which has a different piezometric head (see the test borings and associated groundwater measurements). The glacial sand and gravel deposits are believed to lie in two zones between fifty feet (50') & sixty five feet (65') and approximately eighty five feet (85') to one hundred fifteen feet (115'), respectively. In general, it is expected that groundwater flows towards the southeast.

Through the installation of monitoring wells, a hydrogeological study has been designed to attain the following objectives:

- 1) Confirm the groundwater flow direction and define and characterize the contaminant plume in surficial groundwater on the site and immediately outside the site boundary to the south and east. This will be accomplished by the installation of multiple fifteen (15) shallow monitoring wells (SW-1 - 14 and SW-21 in Figure 2-3). The water samples collected from twelve (12) of these wells will be analyzed for dissolved aluminum, chromium, copper, nickel, silver and zinc, and samples from the following

FIGURE 2-3
GROUNDWATER MONITORING WELL LOCATIONS



remaining three (3) wells will be analyzed for the TAL inorganics: SW-2, SW-5 and SW-8. Samples from SW-2, SW-5 and SW-8 will be analyzed for the TCL organics, while samples from SW-1, SW-3, SW-4, SW-6, SW-10, SW-11, and SW-12 will be analyzed for the TCL volatiles only. All fifteen (15) samples will be analyzed for ammonia and nitrate/nitrite to assist in determining overall groundwater quality.

- 2) Determine the potential for migration of contaminants in surficial groundwater beyond the southern and eastern boundaries of the wetland. This will be accomplished by the installation of six (6) shallow monitoring wells as shown in Figure 2-3 (SW-15 through SW-20). The water samples collected from these six (6) wells will be analyzed for dissolved aluminum, chromium, copper, nickel, silver and zinc. The sample from SW-20 will also be analyzed for the TCL volatile organics to evaluate the potential for contamination from the Numatics, Inc. property lying northeast of the site. All six (6) samples will be analyzed for ammonia, nitrate/nitrite to assist in determining overall groundwater quality.
- 3) Confirm the groundwater flow direction and potential for contamination of the uppermost usable aquifer. This will be accomplished by the installation of five (5) monitoring wells in the 50-65' deep saturated zone in the locations indicated in Figure 2-3. The water samples collected from three (3) wells, IW-1, IW-3 and IW-5, will be analyzed for dissolved TAL inorganics and TCL volatile organics. Samples from the other two (2) wells will be analyzed for aluminum, chromium, copper, nickel, silver and zinc and the TCL volatiles.
- 4) Confirm the groundwater flow direction and potential for contamination of the lower usable aquifer located approximately 85-100' below the existing grade. This will be accomplished by the installation of three (3) monitoring wells in the 85-100' deep saturated zone in the locations indicated in Figure 2-3. The water samples collected from these three (3) wells will be analyzed for aluminum, chromium, copper, nickel, silver and zinc and the TCL volatile organics.
- 5) Determine the hydraulic conductivity of the three saturated zones using slug tests. These tests will be performed on the following wells: SW-4, SW-8, SW-9, SW-11, SW-15, SW-17, IW-1, IW-2, IW-3, IW-4, IW-5, DW-1, DW-2 and DW-3.

Groundwater static elevation level data for the surficial saturated zone will be supplemented with surface water elevation data collected from gauging stakes placed in the locations shown in Figure 2-3.

The groundwater investigation strategy is designed to evaluate the potential for and/or levels of contamination in the surficial saturated zone (most likely to be contaminated) and the aquifers at 50' and 85' BGL. If contamination is discovered in the deeper aquifers, a second-stage RI sampling and analysis program will be developed from the available data to further investigate the affected aquifer(s).

Test borings will be made to provide 1) information regarding the type, variability, and total thickness of unconsolidated glacial sediment in the subsurface underlying this site, and 2) provide a borehole for the installation of monitoring wells.

Groundwater monitoring wells will provide information regarding the depth to the water table, the direction and rate of groundwater flow, and the extent of potential contamination.

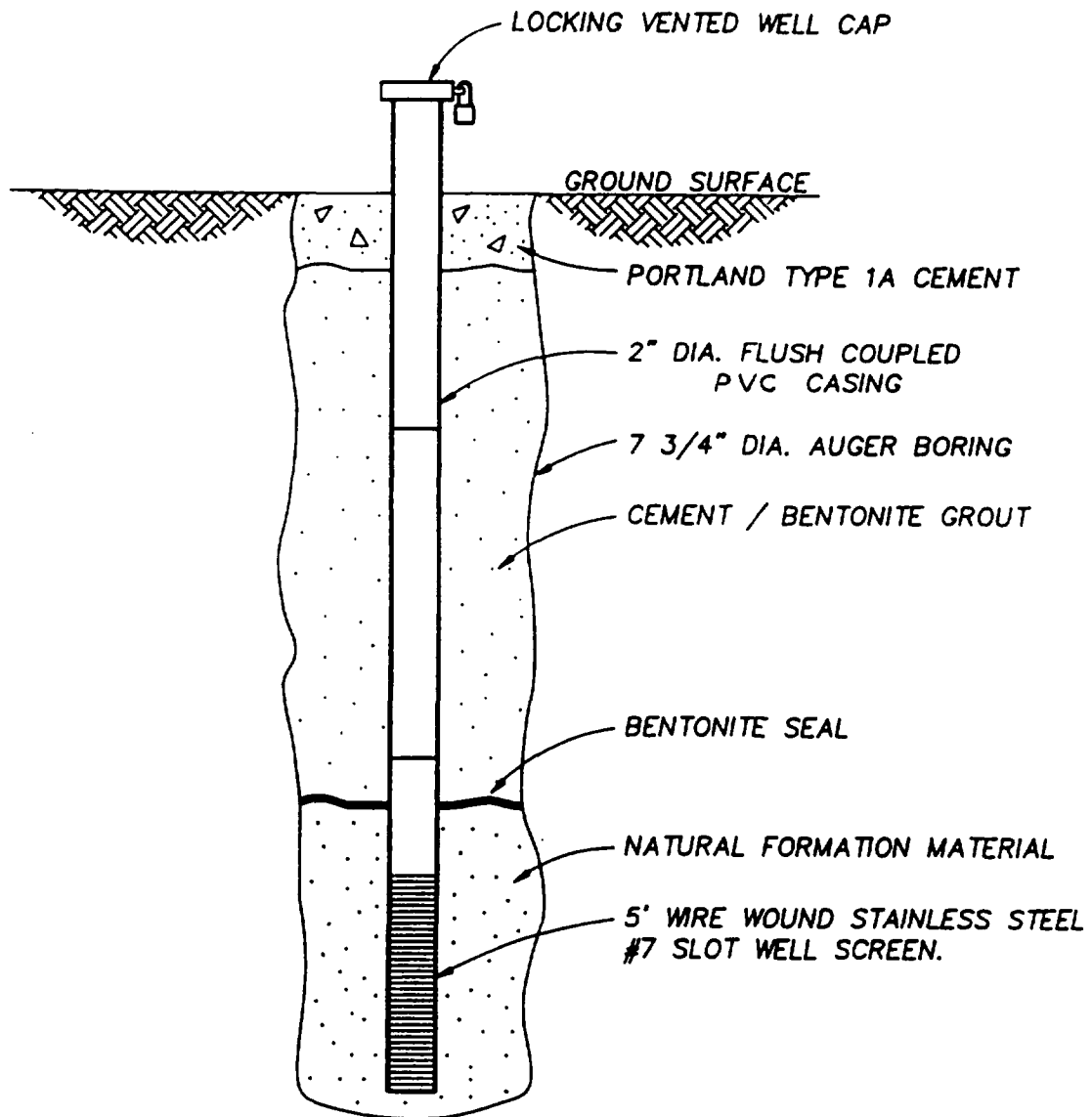
2.5.2 Installation Methodology.

Twenty-nine (29) test borings will be drilled utilizing a continuous-flight, hollow-stem auger drilling technique. The locations of the proposed monitoring wells are indicated on Figure 2-3. The proposed monitoring well depths are presented below:

- 1) The shallow monitoring wells (SW-1 through SW-21) will be constructed in separate boreholes using 3-5' screens set approximately one (1) foot into the uppermost clay layer. Wells from which samples will be analyzed for metals only will be constructed using PVC screens and risers. Wells from which samples will be analyzed for organics and metals will be constructed using stainless steel screens and PVC risers.
- 2) The deeper monitoring wells (IW-1 through IW-5 and DW-1 through DW-3) will be constructed in separate boreholes using 5' screens set so that the top of the screens are approximately one (1) foot below the uppermost boundary of the respective saturated zone. Wells will be constructed using stainless steel screens and PVC risers.

Drilling of boreholes for monitoring well installation will be performed using four and one-quarter inch (4-1/4") I.D. hollow-stem augers fitted with a knockout plug in the lead auger. Each

FIGURE 2-4
MONITORING WELL CONSTRUCTION DETAIL



well will be constructed of two inch (2") diameter flush coupled PVC casing with a five foot length, No. 10 slot, stainless steel or PVC screen and fitted with a plug and vented cap. Each well will extend to one foot (1') above the ground surface, and will be secured with keyed-alike padlocks. A detail of the monitor well construction is presented in Figure 2-4.

The following procedures will be followed to for the installation of the monitor wells.

Step 1: Decontamination

All monitor well casings and screens will be scrubbed with TSP solution followed by a steam cleaning/rinse. The drilling tools and augers will be brushed and steam cleaned prior to drilling each hole. All drilling equipment (i.e. augers, rods, bits, etc.) will be steam cleaned prior to the onset of drilling activities and between boring locations to prevent cross-contamination of boring/coring locations. Steam cleaning will be conducted in a designated area to be established at the onset of field investigation activities. All water and soil generated in the steam cleaning and decontamination process will be contained in a pool near the decontamination pad and will subsequently be placed in containers for proper storage prior to disposal. Drilling equipment will also be steam cleaned upon completion of drilling activities to prevent contamination from leaving site. Upon completion of site investigative activities, samples of decontamination solutions and soils will be collected and analyzed to determine appropriate waste disposal methods. Subsequent transportation and disposal arrangements will then be made.

Step 2: Drilling

Drilling of all monitoring wells will be performed using four and one-quarter inch (4-1/4") I.D. hollow-stem augers fitted with a knockout plug in the lead auger. When drilling boreholes for deeper well installation, a steel outer casing will be installed and will extend until five feet (5') of clay soil has been penetrated. The outer casing will be grouted in place to effectively seal off the shallow water bearing zone from the usable aquifer. Drilling will continue through the cement-bentonite grout plug to the selected well screen depth. If there is mud in the borehole, it will be flushed out and discharged to the site surface, and a deep well will be installed following the methodology described for well installation. Soil samples will be obtained in advance of the hollow stem augers from every five foot (5') interval and change of soil types by means of a split spoon sampler. At locations where clusters of wells are installed, split spoon samples will be collected only from the deepest well. The split spoon sampler will incorporate a liner (either aluminum or brass)

in which the sample will be retained. A standard one hundred forty pound (140#) drop hammer will be used to drive the split spoon sampler, and blow counts will be recorded for each six inches (6") of drive. Since soil samples are not being retained for chemical analysis, split spoon samplers will be cleaned between samples with a detergent wash (Alconox or Liquinox) and tap water rinse to prevent gross cross-contamination of sample intervals. A visual description of the split spoon sample will be logged in the field, noting such features as color, grain size, sorting, roundness, structure, composition, and obvious presence of contamination such as discoloration and odor. A representative aliquot of all split spoon samples will be placed in jars for visual record.

A minimum of two (2) Techna personnel will be on-site for all drilling activities. In addition to other responsibilities, the team will be responsible for screening the ambient air using an HNU Organic Vapor Analyzer and a combustible gas indicator. At the onset of drilling at each monitoring well location, all personnel near the rig will be outfitted in modified Level D protective clothing. Specific permissible levels of organic vapors for upgrading to Level C are set forth in the Health and Safety Plan.

Step 3: Well Screen & Casing Installation

The monitor well will be lowered through the hollow-stem augers to the selected depth. This will be followed by 1) emplacement of five feet (5') of well screen and casing (casing length will be such that it provides for one foot (1') of extension above the ground surface, and the top will be capped to prevent material from entering the well); 2) emplacement of a sand pack to a height of two feet (2') above the top of the screen while simultaneously retracting the augers, thus allowing the sand to settle into the annular space between the well screen and borehole wall while preventing any significant cave-in; and 3) with the auger bottom now located approximately at the top of the sandpack, installation of a two foot (2') bentonite pellet or granular bentonite seal to prevent vertical migration of grout into the well.

Step 4: Grouting

The remaining annular space will be grouted from the bottom up with a bentonite-portland type I cement slurry using a tremie tube while completely retracting the augers from the borehole. The slurry will be mixed with 10 lbs bentonite to 100 lbs Portland Type 1A cement to 10 gallons of water. Slurry will be added with tremie pipe to fill the augers to the top after each auger section is removed. The last three feet (3') will be grouted with bentonite.

Step 5: Well Protection

A locking, protective, steel casing will be installed around the well and will extend a minimum of three feet (3') into the ground.

Step 6: Well Development

After a minimum of 24 hours after well installation, each well will be developed to remove formation fines from the vicinity of the well screen. This will prevent clogging and sedimentation within the well and improve the hydraulic connection between the well and the water bearing formation. Wells will be developed by utilizing an air compressor fitted with a filter, or, by utilizing compressed air cylinders to surge and purge recharging water from the well. Well development water will be discharged to the site surface and will be containerized for proper storage and disposal. The only portion of the air compressor to come into contact with the well or water will be the air hose which will be steam cleaned prior to and after development of each well. The air compressor hose will be lowered into the well to approximately the height of the well screen and compressed air will be jetted into the well, thus forcing air, water and fines to flow up and out of the well. The rate at which compressed air is jetted into the well will be adjusted to create a surging action sufficient to remove formation fines from the well screen and sand pack. The air compressor hose will be slowly lowered to the bottom of the well screen during the course of development. It is difficult to determine the length of time that will be needed for development of each well. Ideally, well development should continue until discharge water is silt-free. However, irrespective of the length of development time, shallow wells in unconsolidated sediments do not always produce silt-free water. Therefore, shallow wells at the Hi-Mill site will be developed for a maximum of four hours or until discharge water is silt-free, whichever is first. In addition, the previously installed monitoring wells will be developed.

Upon development of all monitor wells, a notch will be cut in the top of the inner well casing to serve as a measuring point. A survey will then be performed to determine the measuring point elevations, ground surface elevations, and locations of each monitor well. Static water level (SWL) measurements in monitor wells will be recorded at the time of the survey. All the survey and SWL measurement data will be recorded in the field notebooks. The static water levels will be measured using an Electronic Depth Indicator. The accuracy of this device will be checked by utilizing the wet tape/chalk method.

Auger cuttings and groundwater/drilling fluids produced by the installation and development of monitoring wells will be placed in drums meeting appropriate DOT specifications and transported to the staging area. Samples of the waste materials will be obtained and analyzed for waste evaluation parameters. Upon completion of field investigative activities, arrangements for appropriate disposal will be made.

2.5.3 Collection of Samples for Soil Characteristics

During monitoring well installation activities, nine (9) subsurface soil samples will be collected using shelby tubes and analyzed for the following soil characteristics: grain size distribution, Atterberg Limits and moisture content. Samples of the upper clay stratum and the sands from the 50' saturated zone will be collected from IW-2, IW-4 and IW-5. Samples from the deeper (85') saturated sands will be collected from DW-1, DW-2 and DW-3.

2.6 Groundwater Sampling and Field Analyses

2.6.1 Purpose

Samples will be obtained from all of the monitoring wells previously installed by the Michigan Department of Natural Resources and by Techna to assess potential contamination within the shallow perched water and first usable groundwater aquifers at the Hi-Mill Manufacturing facility site. Information regarding the types of wastewater discharged at the site suggests that the potential exists for selected organic and inorganic contaminants to be present. Therefore, groundwater samples will be analyzed for EPA Contract Laboratory Program TCL organics, TAL inorganics and a short list of TAL metals (aluminum, chromium, copper, nickel, silver and zinc), although not all samples will be analyzed for all parameters (see Section 2.5.1).

2.6.2 Methodology

All sampling and testing procedures will conform to established protocols. Sampling of a well will occur no sooner than fourteen (14) days following the development of that well, thus allowing adequate time for the stabilization of the groundwater system in the vicinity of that well.

Prior to sampling, groundwater level measurements will be taken at each well to calculate the volume of standing water in that well. Three (3) to five (5) well volumes will be purged from each well using a gas driven, air lift pump (e.g. Geoguard system) or dedicated stainless steel bailer prior to sampling. A stainless steel, bottom loading bailer with a teflon check valve will be dedicated to each shallow well for purging and sampling activities. These bailers will be cleaned by a detergent (Alconox or Liquinox) and water wash, a tap water rinse, 10% nitric acid solution rinse, distilled water rinse, laboratory grade methanol rinse, and a distilled water rinse. Each bailer will be fitted with a new piece of teflon-coated wire prior to placement in the well. The measuring tape and water level indicator will be decontaminated before and after use using the procedure stated for cleaning bailers.

Deeper wells will be purged and sampled with a Geoguard air lift sampling system. The body of the sampling system will be decontaminated by sequential washings with organic-free, deionized water, laboratory grade methanol, and organic-free, deionized water. The sampling hose will be decontaminated by pumping organic-free, deionized water through its entire length. Additional flushing of the system will occur while the pump is used to purge the well prior to sampling.

All purge water removed from wells will be collected in drums and stored on-site until completion of field activities. Upon receiving the results of analyses of groundwater samples, arrangements will be made for the appropriate disposal of this water.

Following removal of the appropriate volume of water from the well, the well will be allowed to recharge and will then be sampled. The samples for analysis of organic parameters will be poured directly from the bailers to the laboratory prepared sample bottles. VOA vials will be completely filled to ensure that no headspace remains after capping. Samples for metals analysis will be poured directly from bailers into a Geotech barrel filter. The sample will then be forced under pressure through a 0.45 micron filter directly into laboratory prepared sample bottles or bottles purchased from I-Chem.

The barrel filter will be cleaned prior to and after use by the following procedure: a detergent (Alconox or Liquinox) and water wash, a tap water rinse, a 10% nitric acid rinse and a distilled water rinse. Descriptions of the analytes for each well are presented in Section 5.1, and a summary of the groundwater samples to be collected is shown in Table 2-1.

A summary of the sample bottles, preservatives and holding times is shown in Table 2-2. All sample bottles will be properly labeled and placed on ice while on-site. Accurate records will be kept of all sampling activities and will include, at a minimum, the following information: date,

time, location, sample identification code, depth-to-water measurement, method and volume of water evacuation and sampling technique. Following completion of each day's sampling activities, samples will be packed in sealed coolers and shipped by courier to ENCOTEC in Ann Arbor, Michigan. Samples for inorganics analyses will be trans-shipped to Wilson Laboratories in Salina, Kansas unless or until ENCOTEC receives USEPA approval to perform those analyses. Proper chain-of-custody procedures will be strictly followed.

QA/QC samples for these tasks consist of field duplicates, field blanks, and trip blanks. The duplicates and field blanks will receive 1) dissolved Al, Cr, Cu, Ag, Ni & Zn, and/or 2) TAL inorganics and/or 3) TCL Volatiles, and/or 4) TCL organics analyses. The duplicates and field blanks will be analyzed for the same parameters as the corresponding water sample. The trip blanks will be analyzed for volatile organics when appropriate. Duplicate samples for volatile analysis will be prepared by pouring water from the bailer into a second set of bottles. For water samples collected for organic analyses, three times the normal sample volume for VOA's and two times the normal volume for BNA's and PCB/PEST will be collected for samples designated as matrix spike/matrix duplicate. These will be collected at a rate of 1 per 20 samples or one per sample delivery group, whichever is more frequent.

When field blanks for metals analysis are to be prepared, field blank DI water will be poured into a cleaned bailer or pumped through the Geoguard system, then into the cleaned barrel filter and through the filter, and subsequently into the appropriate container. The field blanks for volatile analysis will follow the same procedure except for the filtering stage. One (1) trip blank will be included for each container containing samples for organic analyses.

Once sample collection has been completed, the appropriate type and number of laboratory prepared or I-Chem purchased sample bottles will be labeled with a date and unique identification code which will indicate the location of samples. All laboratory samples will be identified using an alphanumeric system. Each sample identification will have a lettered prefix which designates the sample type. The prefixes used for Hi-Mill Manufacturing (HM) site will be HMW for water and HMS for soil and sediment. This prefix will be followed by a designation for the sample location. This designation will be the well number for groundwater samples (e.g. -IW3), the grid location and sample depth for grid soil samples (e.g. -E5-2), the symbol TP, BP or WL and sequential sample point designator (and depth designator for sediments) for samples from the proximate wetland pond, background wetland pond and Waterbury Lake, respectively, and associated drainage areas (e.g. -TP-1 or -TP-1-1 as appropriate), the symbol OG and a sequential sample point designator for soil samples from off-grid locations (e.g. -OG-1), the symbol TB with a sequential number designator for trip blanks (e.g. -TB-1), the symbol FB and a sequential number designator for field blanks (e.g.

-FB-1). Field replicates will be identified by the suffix -R appended to the sample number. Field blanks will be designated by appending the suffix FB to the sample number of the sample collected immediately following the field blank. Trip blanks will be indicated by the letters TB followed by a sequential number indicating the number of trip blanks prepared to that time.

Examples of the numbering system for general samples were provided in Section 2.4.5. Examples of additional types of samples collected during the groundwater sampling program are presented below:

- HMW-OW3 = groundwater sample from well OW3;
- HMW-OW3-FB = field blank collected immediately prior to sampling of OW3;
- HMW-TP-3 = trip blank sent to the laboratory in the third shipment cooler.

Sample containers will be labeled with the following information:

- a. Project name and number,
- b. Location of sample (includes depth),
- c. Sample ID number,
- d. Date and time of sample collection,
- e. Names and signature of sampling personnel,
- f. Special remarks (if any), and
- g. Analysis parameters.

The groundwater samples will be stored on ice at four degree Celsius (4°C) until analyses are performed. Chain-of-custody forms will be completed. Samples will be properly packed and shipped by courier in sealed coolers on ice to ENCOTEC in Ann Arbor, Michigan for analyses. The sample documentation, identification and chain-of-custody procedures are outlined in the Quality Assurance Project Plan (QAPP).

Two (2) rounds of samples will be collected from all twenty-nine (29) monitoring wells installed at the Hi-Mill Facility site. The first set of samples will be obtained within forty five (45) days after the monitoring well installation. The second set of samples will be obtained between three (3) and six (6) months after the first sampling episode. The timing of the second set of samples will be dependent on the velocity of the groundwater in the respective saturated zones. Sampling in slower moving zones will be extended toward the end of the 3-6 month period. The sampling teams will consist of two Techna personnel outfitted in Level D protective clothing unless data collected during well installation dictates otherwise.

Each groundwater sample will be measured for pH, specific conductivity, and temperature immediately upon collection.

2.6.3 Field Analysis of pH

Analyses of pH will be performed as follows:

- Calibrate instruments in accordance with the QAPP.
- Ensure the display reads pH.
- Immerse pH probe and thermocouple in solution to be tested.
- Allow a minimum of 30 seconds for the display to stabilize. Record result (in SU) immediately after stabilization to minimize carbon dioxide release from groundwater.

2.6.4 Field Analysis of Temperature

Analysis of temperature will be performed as follows:

- Calibrate instruments in accordance with the QAPP.
- Ensure display reads TEMP.
- Immerse thermocouple into the test fluid. Allow a minimum of 30 seconds for the temperature reading to stabilize. Record temperature result in celsius.

2.6.5 Field Analysis of Conductivity

Analyses of specific conductivity will be performed as follows:

- Calibrate instruments in accordance with the QAPP.
- Rinse probe in DI water.
- Insert conductivity and temperature probes in the solution to be tested, making sure that probes are submerged at least 1-1/2 inches (3.8 cm). Gently move conductivity probe up and down to remove all air bubbles from probe.

- Ensure that the display reads conductivity. If the display blanks out with a figure "1" on the left side of the display, overrange is indicated. This means that the test solution has a higher conductivity than the range selected. Rotate knob to next higher range. For greater resolution, use lowest range for which the display does not blank out (if the 20k range blanks out, report result as 20,000 umhos/cm). Allow a minimum of 15 seconds for the temperature compensation network to stabilize. Record result after stabilization.
- Rinse probes thoroughly with DI water.

2.7 Groundwater Flow Direction and Rate Determination

2.7.1 Purpose

Accurate interpretation of the direction and rate of groundwater flow is necessary in order to assess the fate of groundwater contaminants and thereby the potential environmental and human health impacts. The key components needed to determine the direction and rate of groundwater flow are 1) the groundwater gradient and its orientation and 2) the effective porosity of the aquifer material.

2.7.2 Methodology

The groundwater gradient and its orientation will be determined by plotting and graphing equal potentiometric head contours derived from the static water elevations recorded from each of the monitor wells. Static water elevations will be measured in all wells at one-month intervals during the first three months of the RI/FS program and at three-month intervals during the succeeding nine months. The elevation data will be recorded in the field notebooks, and the Electronic Depth Indicator and wet/chalk tap method for measuring will be used. All the data will be summarized in a tabular format so that groundwater trends can be determined. Representative sets of data will be used for constructing the groundwater contour maps. Groundwater contour maps will be generated with a computer and plotter. The groundwater gradient and flow direction will be measured directly off the maps.

The groundwater flow rate or seepage velocity (V) will be determined by using a form of Darcy's Law: $V = ki/n$

Where: V = velocity

k = hydraulic conductivity

n = effective porosity

i = hydraulic gradient

The hydraulic conductivity of the aquifer will be determined from slug tests performed on the following selected monitoring wells: DW-1, DW-2, DW-3, IW-1, IW-2, IW-3, IW-4, IW-5, SW-4, SW-8, SW-9, SW-11, SW-15 and SW-17. The SOP for performance of slug tests can be found in Appendix C.

Correlation of groundwater and surface water elevations will be accomplished by evaluating and comparing the surface water static levels measured from gauging stakes placed in the locations shown in Figure 2-3. The elevations of these gauging stakes will be surveyed after installation, and water level measurements will be made each time static water levels in the monitoring wells are measured.

2.8 Surface Water and Sediment Sampling

2.8.1 Purpose

The wetland lying east and southeast of Hi-Mill contains a pond where previous investigations conducted by the MDNR have indicated that elevated levels of aluminum, chromium, copper and zinc may be present in the water and/or sediments. The purpose of this task will be to confirm the presence of these metals in the two media, measure their levels, and determine if those levels are elevated with respect to typical wetlands in the area.

Analysis data for samples from the target wetland will be compared to data from background samples collected from a similar wetland pond lying southwest of the Hi-Mill site.

2.8.2 Methodology

Sediment and surface water sample locations will be established in the pond southeast of Hi-Mill, in Waterbury Lake and north of M-59 in the locations shown in Figure 2-5. These locations were selected to be representative of the pond and proximate areas of Waterbury Lake. The two northeastern samples will be collected from a drainage area leading from the Numatics, Inc. property to the pond to evaluate the potential for contaminant contribution from the Numatics property. Four (4) background water and sediment samples will be collected from a wetland, of the same characterization as the target wetland, lying approximately 1000 - 1500' southeast of Hi-Mill as shown in Figure 2-6.

Seven (7) surface water samples from the target pond/Waterbury Lake area and three (3) from the background wetland will be analyzed for aluminum, chromium, copper, nickel, silver, zinc and Cr^{+6} . The following four (4) water samples will be analyzed for Cr^{+6} and the complete TAL inorganic parameter list: one water sample from the background wetland, two from the western edge of the target pond, and one from the drainage swale leading from the Numatics property. One (1) water sample from the southeast (target) pond, one (1) water sample from Waterbury Lake and one (1) sample from the background wetland will also be analyzed for ammonia, nitrate/nitrite.

Samples from all seventeen (17) sediment sampling locations will be collected from the upper foot of sediment. Samples from the five (5) western points in the target wetland will also be collected from 1' - 2' below the sediment surface. Fifteen (15) sediment samples from the target pond/Waterbury Lake area and three (3) from the background wetland will be analyzed for aluminum, chromium, copper, nickel, silver, zinc and Cr^{+6} . The following four (4) sediment samples will be analyzed for Cr^{+6} and the complete TAL inorganic parameter list: one sediment sample from the background wetland, two from the western edge of the target pond, and one from the drainage swale leading from the Numatics property.

Surface water samples will be collected by wading or from a small boat launched into the ponds. Samples will be collected from a depth of approximately 6" below the water surface. Samples will be collected with a dedicated plastic bottle which will be pre-cleaned by a TSP detergent and water wash, followed by a tap water rinse, 10% nitric acid rinse, and a deionized water rinse. The bottles will be sealed prior to use. Collected samples will be transferred to the shore, where they will be filtered under pressure using a Geotech barrel filter to remove suspended sediments. The filtrate will then be split into aliquots for analysis of metal species. Sample containers and preservatives are summarized in Table 2-2. All samples will be logged and labeled as described in the QAPP.

FIGURE 2-5
WETLAND SAMPLING DIAGRAM

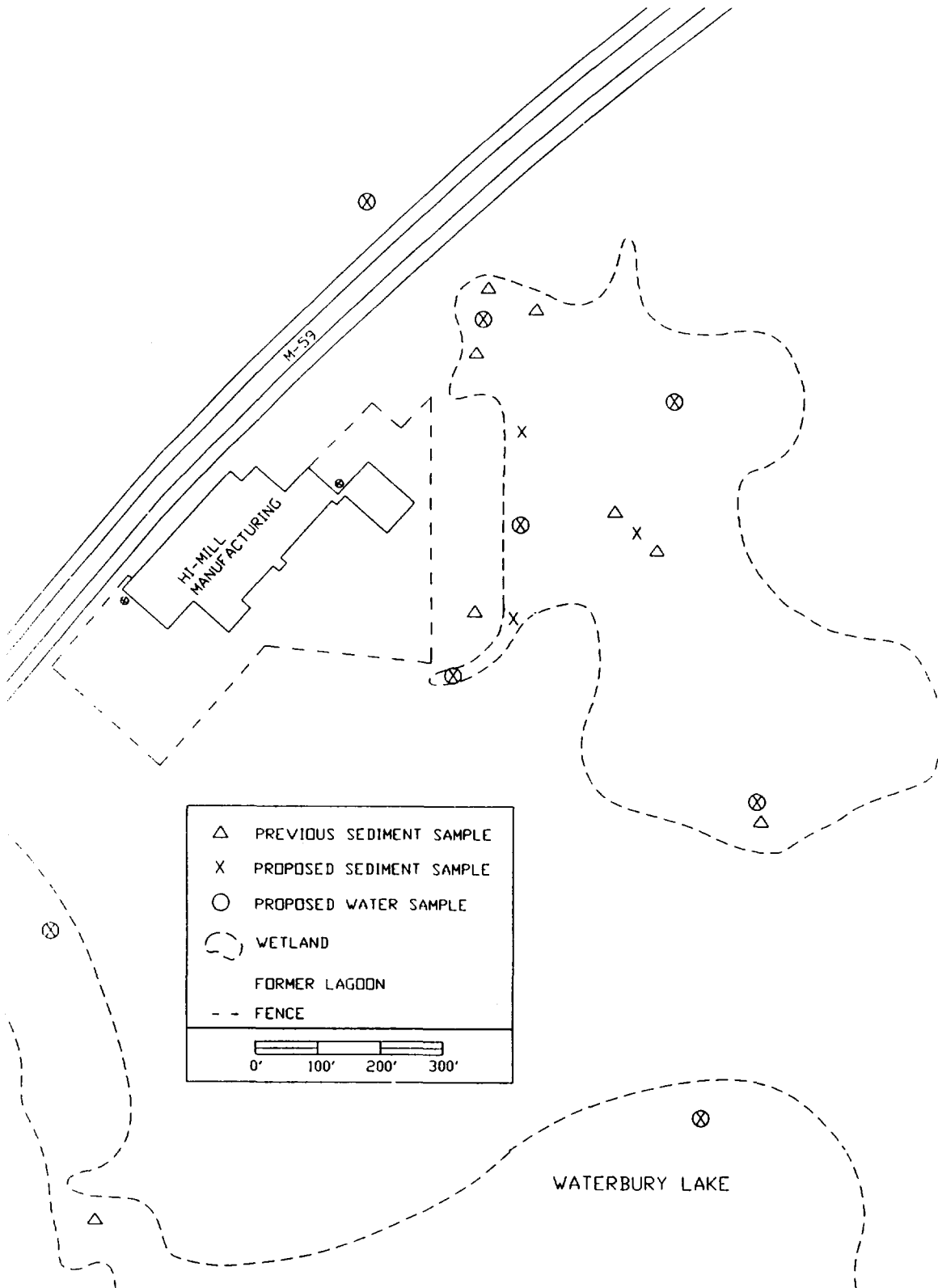
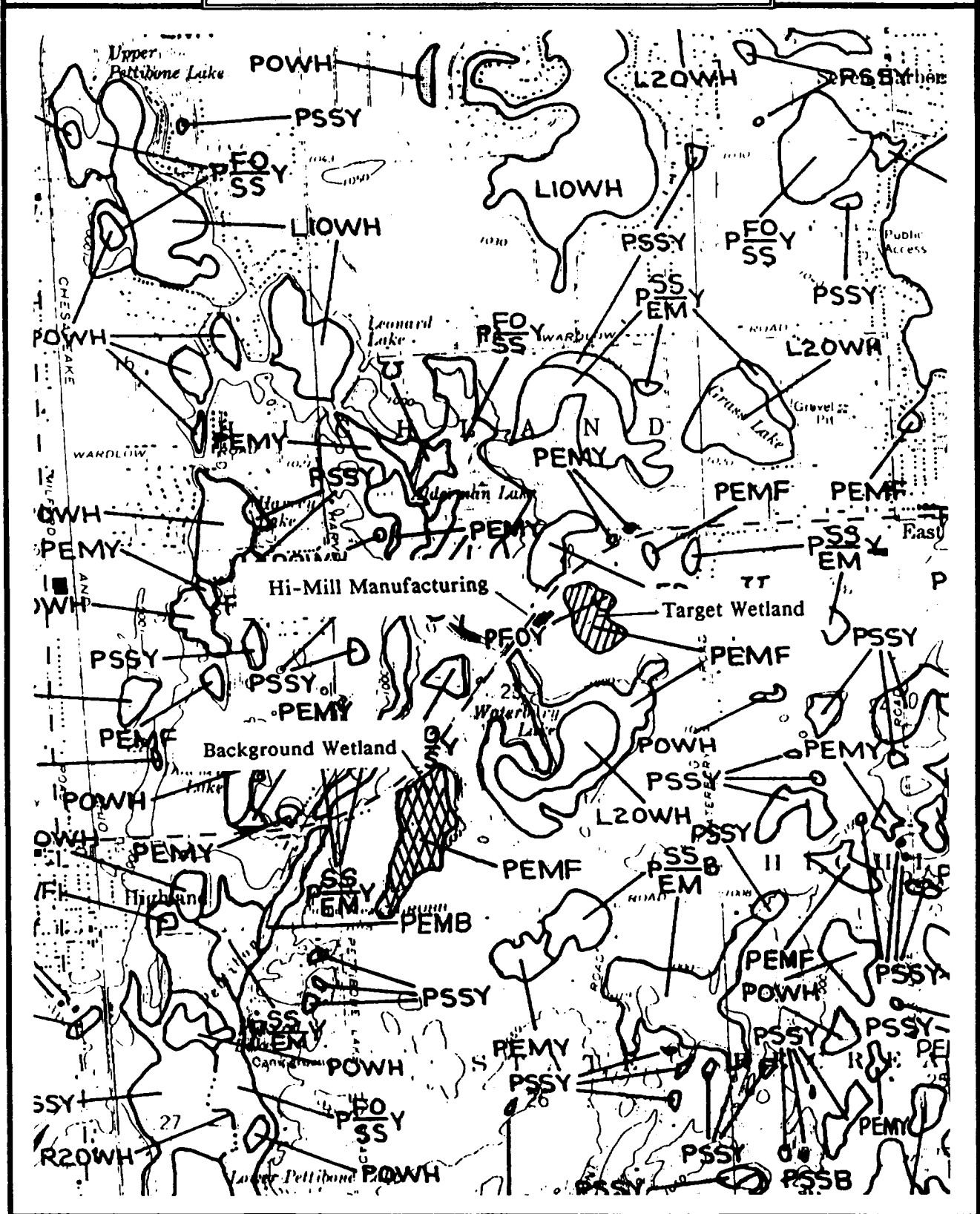


FIGURE 2-6

BACKGROUND WETLAND LOCATION MAP



Sediment samples will be collected with a split spoon or other appropriate sampler driven into the upper two (2) feet of sediment. The samplers will be pre-cleaned by a TSP detergent and water wash, followed by a tap water rinse, 10% nitric acid rinse, and a deionized water rinse, and will then be wrapped in aluminum foil prior to use. Samples will be collected from the sampler, as described in Section 2.4.4, from the upper 6" of sample. For the five (5) samples collected from the western edge of the pond, additional sediment samples will be collected from the 1.5 -2' portion of the sampler. Samples will be placed into plastic bottles for analysis of appropriate metals species. Sample containers and preservatives are summarized in Table 2-2. All samples will be logged and labeled as described in the QAPP.

Surface water and sediment duplicates will be obtained during the sampling task as indicated in Table 2-1. Duplicates will be prepared by homogenizing, then splitting one sample of each media. Duplicate samples will be sent to ENCOTEC with a false identifier, and the actual sample identifier will be entered in the log book. Field blanks for the surface water sampling will be obtained during water sampling by pouring the field blank deionized water into a collection bottle, then filtering it and preparing it for shipment as for the actual samples. The sediment duplicates will be analyzed for the TAL inorganics and Cr^{+6} , and the water duplicates and field blank will be analyzed for the TAL inorganics, Cr^{+6} and ammonia, nitrate/nitrite as shown in Table 2-1.

2.9 Data Evaluation

Site investigation analysis is designed to verify the site data with respect to its sufficiency to meet the RI/FS objectives. The primary objective of the site investigation analysis is to determine whether enough data has been gathered to adequately perform an Endangerment Assessment and Feasibility Study. The site investigation data will be analyzed throughout the course of the RI for quality control (accuracy, precision, completeness, representativeness and comparability) and to refine subsequent activities. Upon completion of all field activities, a thorough review will be conducted and a summary will be prepared of all site investigations and results. The site data will be integrated to fully define contaminant concentrations found in each of the environmental pathways and will be presented graphically to depict average and/or hot-spot concentrations of critical indicator parameters using isopleth contour maps and other displays as applicable.

As a first step, all chemical, geological, and hydrogeological data obtained during the site investigation will be summarized and reviewed. For chemical data, the initial review will focus on the number of samples taken and analyzed, the locations sampled and the sample media. A thorough

review will be made of the following field and laboratory procedures employed to document sampling and analysis methods: sample packaging, preservation and change-of-custody procedures; possible sample degradation prior to analysis; analytical methods verification and calibration procedures; quality assurance/quality control methods. The analytical data will be reviewed to determine whether the data are reasonable and consistent, whether there are noticeable trends, and whether there are grossly diverse results. At this point, the data will be validated or shown to contain uncertainties that must be considered when formulating conclusions.

All field data will likewise be summarized and analyzed. Geological units encountered at the site will be depicted in cross-sectional diagrams, and the physical characteristics of the units, as well as the regional extent and significance, will be described in detail. Groundwater flow paths will be delineated on groundwater contour maps and the potential for vertical movement of groundwater will also be evaluated.

Data assessment and validation will be the responsibility of Techna and Region V. Data validation will follow guidelines in EPA technical directive documents "Functional Guidelines for Evaluating Analyses", (2/1/88) and "Functional Guidelines for Evaluating Inorganics Analyses" (7/1/88).

Following the completion of the data review, a summary report will be prepared. This report will present a determination of the sufficiency of investigative data in terms of quality and quantity to define the nature and extent of contamination to adequately perform the Endangerment Assessment and Feasibility Study.

2.10 Additional Investigations

Additional on-site and/or off-site investigations will be performed if the site investigation analyses indicate that a contamination problem has resulted from on-site activities, and the current investigative data is not sufficient in quality or quantity to support a feasibility study. Additional off-site remedial investigation may also include (if necessary) computer groundwater flow and contaminant transport modeling to facilitate in the determination of contaminant fate and/or remediation alternatives. Chemical, benchscale and/or pilot testing may also be necessary to adequately determine data required for the FS.

If it is determined that off-site contamination has resulted from on-site sources and additional remedial investigation is required, additional groundwater investigations will be designed

such that the nature and extent of groundwater contamination is sufficiently determined. Additional investigations will be performed to obtain the necessary data to perform the Feasibility Study. Any off-site investigation will also entail gathering additional existing (background) data pertinent to the study.

If the results of the water and sediment sampling and analysis activities in the marsh/pond southeast of the site indicate that contamination is present at levels that could be harmful to aquatic systems, then an additional biota study may be necessary to evaluate the potential impairment and any causal factors.

The design of any additional investigations will be prepared as an addendum to this document.

2.11 Endangerment Assessment

The objective of an endangerment assessment is to evaluate the potential pathways of contaminant migration from a contaminant source, to determine potential receptors that may be exposed along those pathways and to determine the potential harm that could result from the exposure. Depending on the indicator chemicals identified at the site, the endangerment assessment may also include a toxicological assessment of identified contaminants released from the source. The Endangerment Assessment will comply with all Applicable or Relevant and Appropriate Requirements (ARARs).

The endangerment assessment will be comprised of an initial source-pathway-receptor analysis for the contaminants of concern. If data collected during the RI at Hi-Mill indicates that contaminants are leaving the site, a toxicological assessment of selected critical contaminants will be prepared. This assessment will consist of the activities described in the following paragraphs.

2.11.1 Selection of Indicator Chemicals

The selection of indicator chemicals will involve identification of on-site contaminants, determination of environmental concentrations along the selected pathway based on RI monitoring data, estimation of representative receptor values and evaluation of potential for transport to receptors. The initial list of indicator chemicals will be derived from a comparison of environmental concentrations to known USEPA health and risk based criteria and standards. The indicator

chemical(s) selected should represent the most toxic, mobile and persistent chemicals (highest risk chemicals) at the site.

2.11.2 Estimation of Exposure Point Concentrations

If human exposure can be demonstrated, then the next step in the endangerment assessment will be to estimate the concentrations of indicator chemicals at the exposure point(s). A combination of site monitoring data and exposure modeling may be necessary for this step. The most appropriate model will be selected from the "Superfund Exposure Assessment Manual" and other guidance documents including, but not limited to, "Procedures for Dispersion Modeling and Air Monitoring for Superfund Air Pathway Analysis." In this step, important pathways will be identified, and ambient concentrations of the target chemical will be modeled from the source(s) to the receptor (human exposure). The predicted concentrations will be compared to "applicable and appropriate standards" (ARAR) criteria, advisories, guidance, or standards (e.g. ambient water quality criteria, drinking water standards, etc.).

2.11.3 Estimation of Chemical Intakes

The calculation of human intake of target contaminants considers environmental concentrations derived in the exposure assessment along with intakes from air, groundwater, surface water, and ingestion of contaminated soil, fish and other consumables as appropriate. Standard assumptions about human body weight, air volumes inhaled, and water, fish, soil, food, etc. ingested will be used. Chronic daily intakes will be calculated from formulas incorporating human intake factors, short and long term concentrations, exposure duration and bioaccumulation.

2.11.4 Toxicity Assessment

In the event that ARARs are not available for all the indicator chemicals identified at the site, the fourth step will be a toxicity assessment. Such an assessment will be based on the most recent valid toxicity values. Toxicity values of interest include 1) acceptable intakes for subchronic and chronic exposures and 2) carcinogenic potency factors. These values are derived from USEPA-based empirical data on ingestion and inhalation; they are listed in an appendix to the "Superfund Public Health Evaluation Manual" (October 1986) and subsequent quarterly updates of the Health

Effects Summary Tables. The currentness of values selected for use in the toxicity assessment will be verified with the USEPA prior to use.

2.11.5 Risk Characterization

The final step of the endangerment assessment is risk characterization. Risk characterization compares the projected intakes with the acceptable intakes for non-carcinogenic chemicals, and the calculated risks with the target risks for carcinogens. The Hazard Index approach will be used for estimating non-carcinogenic effects caused by multiple chemicals. This index combines multiple sub-threshold exposures for indicator non-carcinogens which are assumed to yield an adverse effect which is proportional to the sum of the ratios of sub-threshold exposures to acceptable exposures. For potential carcinogens, risks will be calculated using chronic daily intakes (ingestion and inhalation) and respective potency factors. The total potential carcinogenic risk, along with the reliability of the estimate, will be summarized in the endangerment assessment.

Techna is aware of the many uncertainties and assumptions, such as data gaps, incomplete toxicity data, sample variation, risk additivity, modeling assumptions, and extrapolations of data (e.g dosages, test species, chemical structures), associated with risk assessments. Therefore, all assumptions and known uncertainties involved in the public health evaluations will be documented and reported.

2.12 Reporting

Reporting during the RI will consist of monthly progress reports, technical memoranda, a draft RI report and a final RI report. The contents of these reports are summarized below.

2.12.1 Monthly Progress Reports

Monthly progress reports will be prepared and submitted to the USEPA during the course of the RI. These reports will contain the following information:

- Summary of work completed during the reporting period,
- Status of work in progress,
- Status of performance schedule,
- Problems and changes in workplan implementation,
- Steps taken to correct, or in response to, problems encountered,
- Activities projected for the following reporting period, and
- Copies of field and laboratory data.

Reports will be submitted on or before the fifteenth (15th) day of the month following the reporting period.

2.12.2 Technical Memoranda

Technical memoranda will be prepared and submitted to the USEPA within sixty (60) days after the conclusion of chemical analysis activities and after completion of the endangerment assessment. The chemical analysis memorandum will include the results of chemical analyses performed on samples collected during the RI field activities and initial evaluations of the data. The endangerment assessment memorandum will be prepared concurrently with the RI report. This memorandum will present a summary of the potential impacts of the Hi-Mill site on human health and the environment.

2.12.3 Remedial Investigation Report

A draft Remedial Investigation Report will be prepared upon completion of the site analysis. This report will characterize the site and provide summaries of data collected and conclusions drawn from all investigative activities. The report will contain applicable site background information, a description of site features, a summary of RI methodologies and results, and ecological and hydrogeological evaluations of the nature and extent of contaminant impact.

Three (3) copies of the draft report will be submitted to the USEPA for comment. After USEPA review, comments will be addressed, and a final report will be issued within ninety (90) days after final approval of the subsequent draft by the USEPA.

3.0 FEASIBILITY STUDY

3.1 Introduction

The purpose of this feasibility study will be to identify and appropriate remedial actions and to evaluate potential remedial technologies that may be needed at the Hi-Mill site. The feasibility study will draw from the Remedial Investigation and Endangerment Assessment (EA), as well as all previous site investigations. In order to develop and evaluate these remedial alternatives, the first step will be a detailed description of the current situation. This description will include any actual or potential exposure pathways that must be addressed by remedial action.

3.2 Identification Preliminary Remedial Technologies

Based upon a review of the EA and site specific problems (if any) identified in the RI, a master list of potentially feasible, remedial technologies will be created. This list will draw extensively from the EA portion of the RI. The purpose of this list is only to identify potentially applicable remedial technologies and to determine what additional information, if any, is required in order to evaluate these alternatives.

3.3 Development of Potential Remedial Alternatives

Based upon the results of the RI and Subtask 3.2 of the Feasibility Study, the potential remedial technologies will be further developed. This development includes two phases.

Phase 1: The establishment of remedial response objectives which may include source control, transport mitigation, or inception.

Phase 2: The identification of remedial alternatives which meet the objectives defined in No. 1, as well as any other appropriate site considerations. Alternatives will

include at a minimum the no-action alternative and alternatives that meet ARARs. Alternatives will be reviewed and compared on the basis of ARARs.

3.4 Screening of Potential Remedial Technologies

The purpose of this screening is to eliminate technologies that are clearly infeasible and inappropriate prior to more detailed evaluations. Considerations in screening will include environmental protection (including ARARS), environment effects, technical feasibility and cost (total present value). Any or all of the potential remedial technologies that clearly are not desirable alternatives will be eliminated without further review.

3.5 Evaluation of Alternatives

The potential remedial technologies remaining after the initial screening will be evaluated on the basis of technical analysis, environmental analysis, public health, institutional requirements, cost analysis, and cost-effectiveness. The nine criteria which will be evaluated are:

1. State acceptance;
2. Protection of public health and the environment;
3. Compliance with ARARS;
4. Short-term effectiveness;
5. Long-term effectiveness and performance;
6. Implementability;
7. Community acceptance;
8. Reduction of toxicity, mobility or volume of contamination; and
9. Cost.

A preliminary environmental assessment (EA) for each alternative will be prepared. The EA will include an evaluation of both the beneficial effects of the remedial alternate. The no-action alternative will serve as the baseline for all comparisons for the EA. The public health analysis will

include an assessment of how well the alternative mitigates long-term exposure and protects the public both during and after the remedial action. The no-action alternative will also be used as a baseline for this health analysis. The public health analysis is intended only to measure relative reductions in terms of the no-action alternative. It will not be a quantitative risk assessment. Institutional analysis will consist of all regulatory, permitting, community relations, and other additional regulatory actions that will be required for each alternative. Cost analysis will consist of both capital and operation and maintenance cost for each alternative. Both monetary costs and associated non-monetary will be included in this analysis. Evaluation of cost-effective alternatives will include a combination of present worth of total costs, health information, environmental effects, technical aspects of remedial alternatives, and the extent to which ARARS are met, as well as any other applicable factors.

3.6 Preparation of Feasibility Study Report

After the alternatives are fully evaluated in Subtask 3.6, a draft FS report will be prepared and distributed to Hi-Mill, the USEPA and the MDNR for review and comment. Based upon the review and comments obtained, a final FS report that includes a summary of any or all public comments received on the preliminary report will be prepared and distributed to the USEPA and the MDNR.

4.0 PROJECT ORGANIZATION

This section describes the project organization for the Hi-Mill Remedial Investigation/Feasibility Study in Highland, Michigan. Figure 4-1 presents a graphical depiction of the project organization.

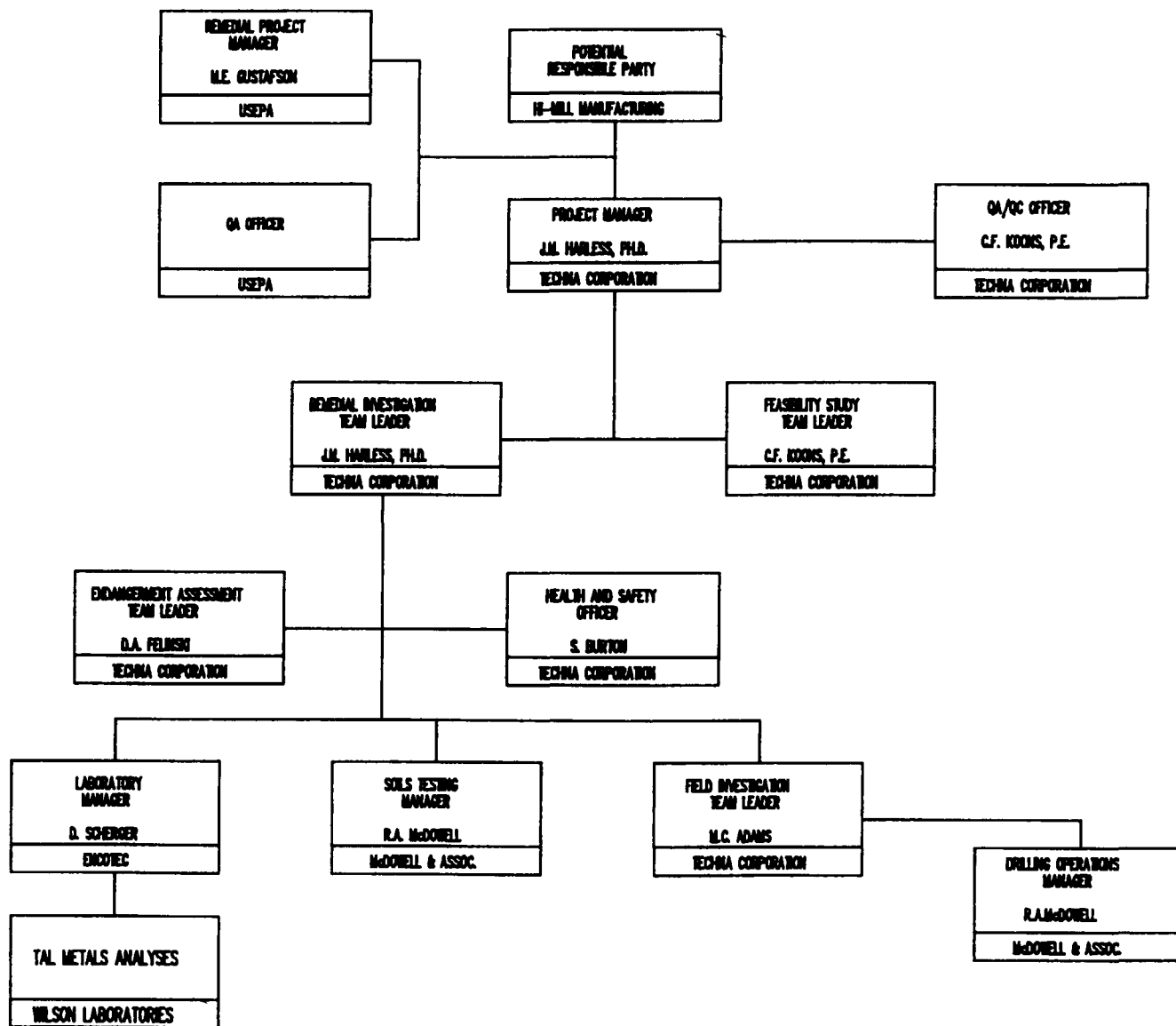
4.1 Project Organization

The following is a summary of the key Techna personnel assigned to the Hi-Mill RI/FS project:

<u>Name</u>	<u>Responsibility</u>
James M. Harless, Ph.D.	Project Manager
Charles F. Koons, P.E.	QA/QC Officer
James M. Harless, Ph.D.	RI Team Leader
Sarah Burton	Health and Safety Officer
Mary C. Adams	Field Investigation Team Leader
David A. Felinski	Endangerment Assessment Team Leader
Charles F. Koons, P.E.	FS Team Leader

The resumes for these persons are attached in Appendix D of this document.

FIGURE 4-1
PROJECT ORGANIZATION CHART



4.2 Subcontractors

The subcontractors that will be used for specific tasks in the Hi-Mill RI/FS program are listed below:

Soil boring and monitoring well installation:

McDowell and Associates, Inc.
21355 Hatcher Avenue
Ferndale, Michigan

Aerial photography and base mapping:

Mason L. Brown and Son
110 Madison
Detroit, Michigan

Consulting Hydrogeologist

Steven J. Wright, Ph.D.
113 Engineering 1A
The University of Michigan
Ann Arbor, Michigan

Soils testing and evaluation:

McDowell and Associates, Inc.
21355 Hatcher Avenue
Ferndale, Michigan

Chemical analyses

Environmental Control Technology Corporation
3983 Research Park Drive
Ann Arbor, Michigan

Wilson Laboratories (TAL metals only)
P.O. Box 1820
Salina, Kansas

5.0 PERFORMANCE SCHEDULE

The schedule to implement the RI/FS as described in this work plan is illustrated in Figure 5-1. The schedule will be revised if the site investigation task indicates that additional investigation is needed. The revised schedule will be submitted with any required workplan addenda. A summary of project progress as measured against the schedule will be included with each monthly report.

FIGURE 5-1
PROJECT SCHEDULE

HI-MILL MANUFACTURING REMEDIAL INVESTIGATION

SITE MAPPING
SITE OPERATIONS PREPARATION
MONITOR WELL INSTALLATION
MONITOR WELL SAMPLING
SOIL SAMPLING
SURFACE WATER AND SEDIMENT SAMPLING
LABORATORY ANALYSES
SITE INVESTIGATION ANALYSIS
ADDITIONAL INVESTIGATION
ENDANGERMENT ASSESSMENT
DRAFT RI REPORT PREPARATION,
REVIEW AND REVISION
EPA REVIEW OF DRAFT REPORT
REVISIONS OF DRAFT REPORT AND
REVIEW AND REVISION OF FINAL
REPORT
EPA REVIEW AND APPROVAL
OF FINAL REPORT
MONTHLY PROGRESS REPORT

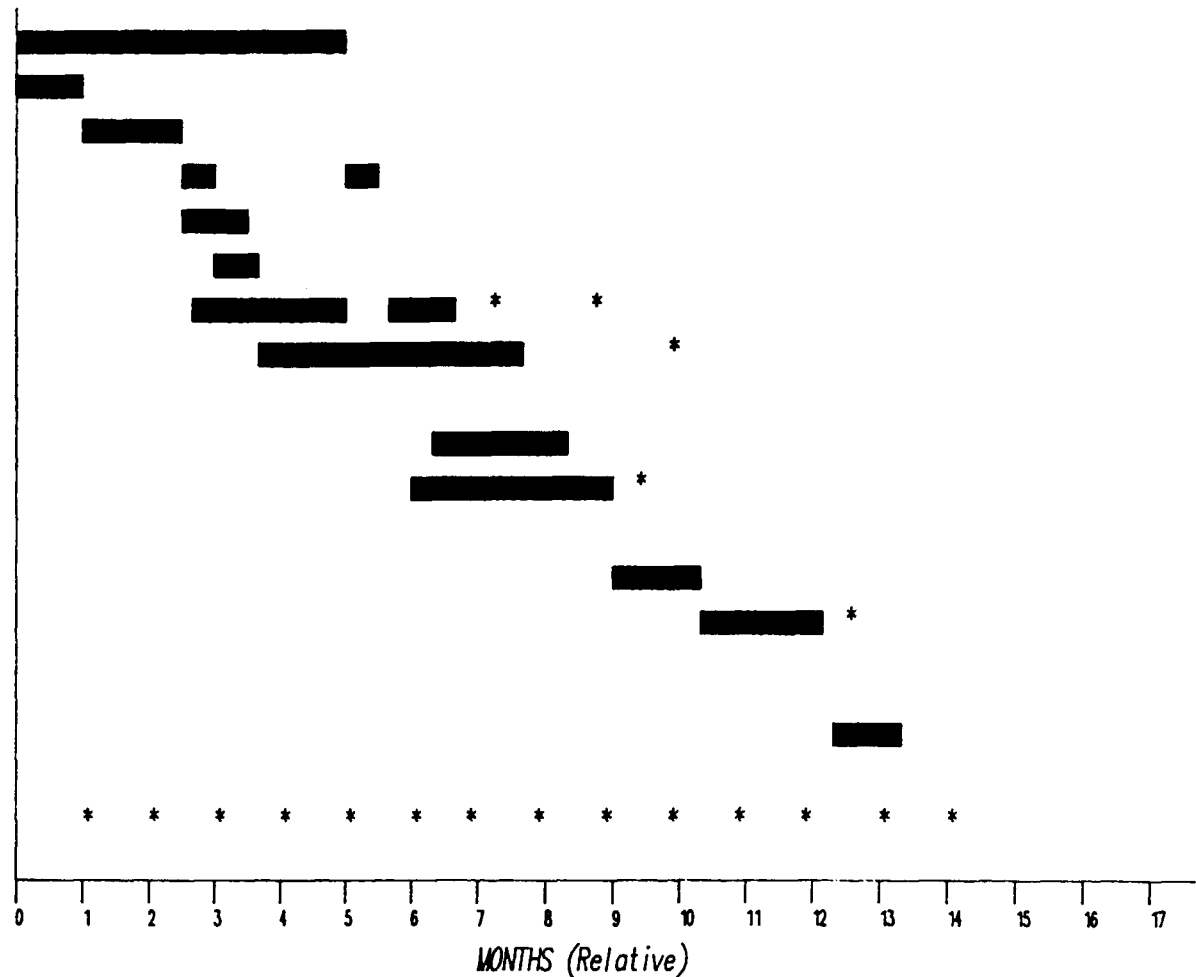
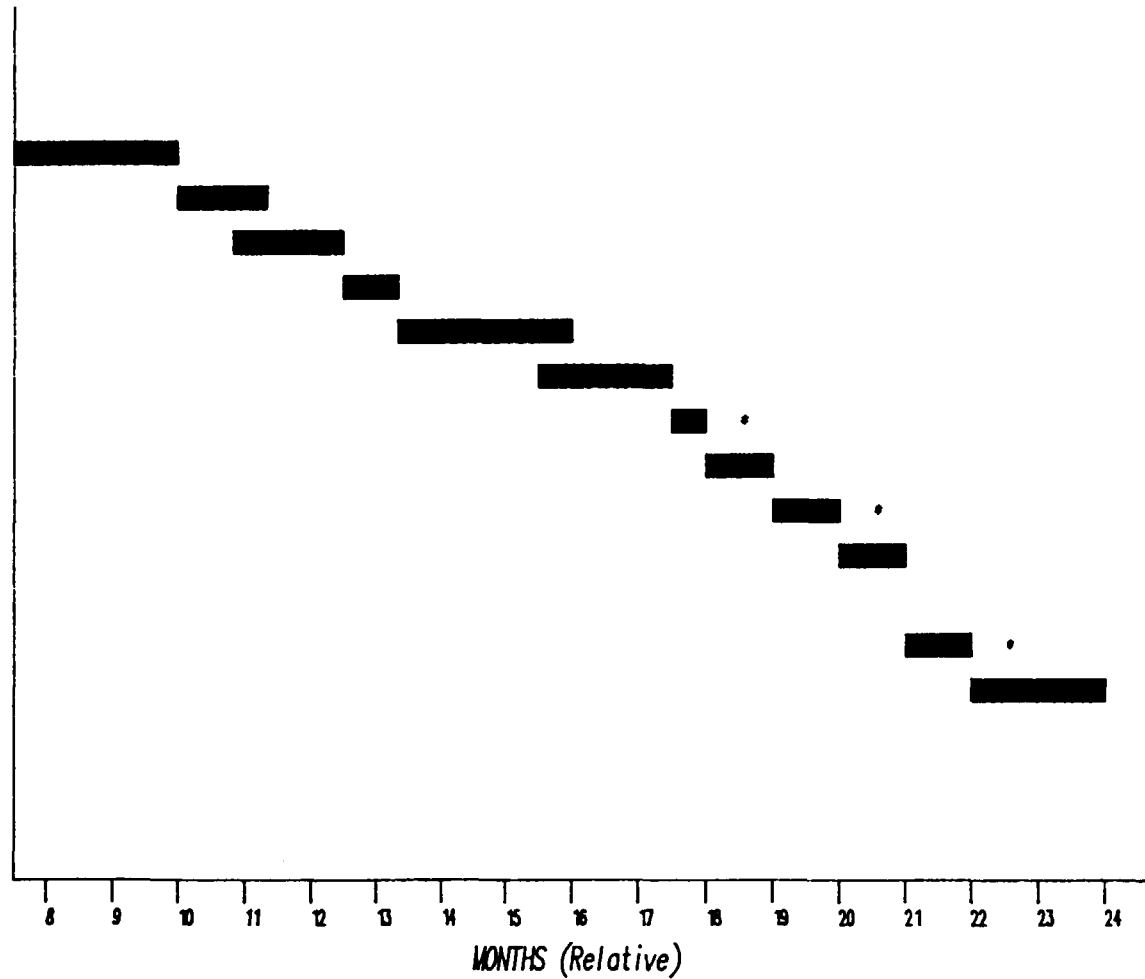


FIGURE 5-1 (Cont.)
PROJECT SCHEDULE

HI-MILL MANUFACTURING FEASIBILITY STUDY

IDENTIFY/REVIEW REMEDIAL ACTION OPTIONS
IDENTIFY PRT
DEVELOP AND REVIEW PRT
SCREEN PRT
EVALUATE AND REVIEW ALTERNATIVES
PREPARE/REVIEW DRAFT FEASIBILITY STUDY
REVISE DRAFT FEASIBILITY STUDY REPORT
EPA REVIEW OF DRAFT REPORT
PREPARE FINAL FEASIBILITY STUDY REPORT
EPA REVIEW OF FINAL FEASIBILITY
STUDY REPORT
REVISE FINAL FEASIBILITY STUDY REPORT
PUBLIC COMMENT



6.0 SITE SAFETY PLAN

6.1 Introduction

This Health and Safety Plan was designed to protect employees from all possible hazards encountered during field investigations of the Hi-Mill Manufacturing Company site. The guidance manual Occupational Safety and Health for Hazardous Waste Site Activities prepared by NIOSH, OSHA, EPA, and The U.S. Coast Guard, serves as the basis for this document. The information presented in the manual has been evaluated in light of conditions specific to the Hi-Mill site and adjusted to insure that the safest possible working conditions are attained.

All operations, tools and equipment at the site will conform to the requirements of 29 CFR 1910.120 (Hazardous Waste Operations and Emergency Response) and with applicable requirements of the OSHA Construction and General Industry Standards.

6.2 Site Description

6.2.1 Location

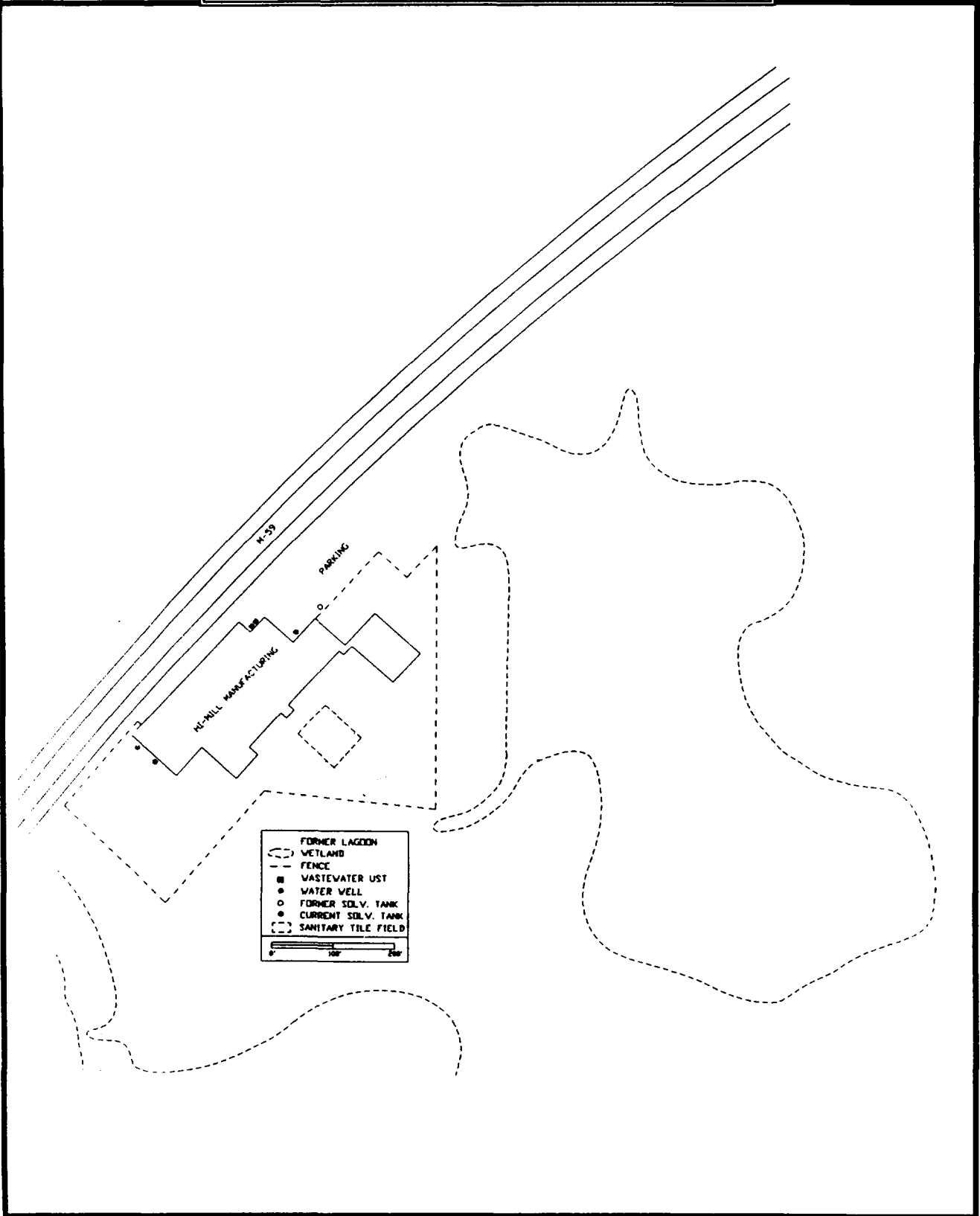
Hi-Mill Manufacturing Company occupies a 2.5 acre site located at 1074 Highland Road (Michigan State Highway 59), Highland Township, Michigan. The site is surrounded by the State of Michigan's Highland Recreational Area. The company has been in operation since 1946, fabricating copper, aluminum, and brass tubular parts.

A diagram of the site, including the surrounding wetlands is shown in Figure 6-1. A wetland area lies immediately east of the site, and Waterbury Lake lies to the south. Data from USGS topographical maps and an MDNR hydrogeological report indicate that surface run-off and perched water from the site both flow toward the eastern wetland and Waterbury Lake.

6.2.2 Background

Hi-Mill Manufacturing Company discharged process wastewater from metal finishing activities to an unlined lagoon south of the production building until 1983. The results of three environmental investigations performed by the MDNR indicate elevated levels of toxic metals in the

FIGURE 6-1
SITE DIAGRAM



perched water east of the former lagoon and in sediment samples from the wet land. The metals of concern are Aluminum, Chrome, Copper, and Zinc.

In addition, recent analysis of groundwater samples obtained from the Hi-Mill production wells has revealed low levels of trichloroethylene contamination. The maximum concentration detected was 24 parts per billion. Preliminary hydrogeological investigations have shown that the contamination is localized and does not extend beyond the area of the production wells.

The Hi-Mill site is a proposed addition to the National Priority List of Superfund sites.

6.2.3 Weather

The remedial investigation is not expected to be conducted when adverse weather conditions, such as extreme heat or cold, could pose a health or safety hazard. There is a remote possibility of flooding on the southeastern site boundary should a period of heavy rains occur.

The prevailing winds for Highland Township area are West-Southwest, according to the Michigan Department of Agriculture, Climatology Office.

6.3 Entry Objective

This three-phase remedial investigation is designed to determine 1) the potential environmental impact of past site activities at the Hi-Mill facility and 2) if current site activities continue to result in environmental impairment. The investigation will involve conducting soil and perched water sampling, collection of water and sediment samples from the surrounding wetland and Waterbury Lake, and installation of a series of nested monitoring wells. The proposed locations of the borings, wells, and samples are shown in Figures 6-2, 6-3, and 6-4.

FIGURE 6-2
SOIL SAMPLING DIAGRAM

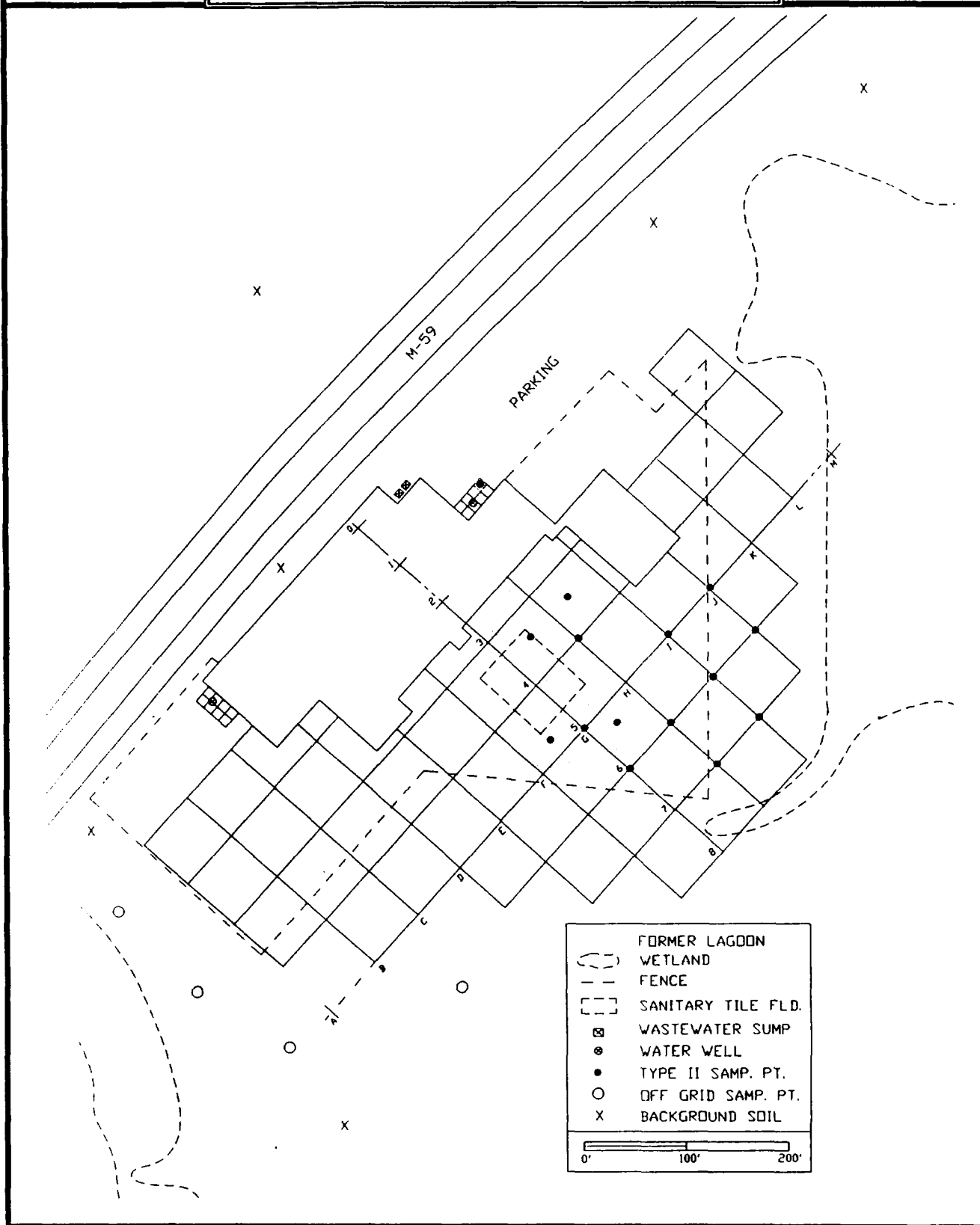


FIGURE 6-3
GROUNDWATER SAMPLING DIAGRAM

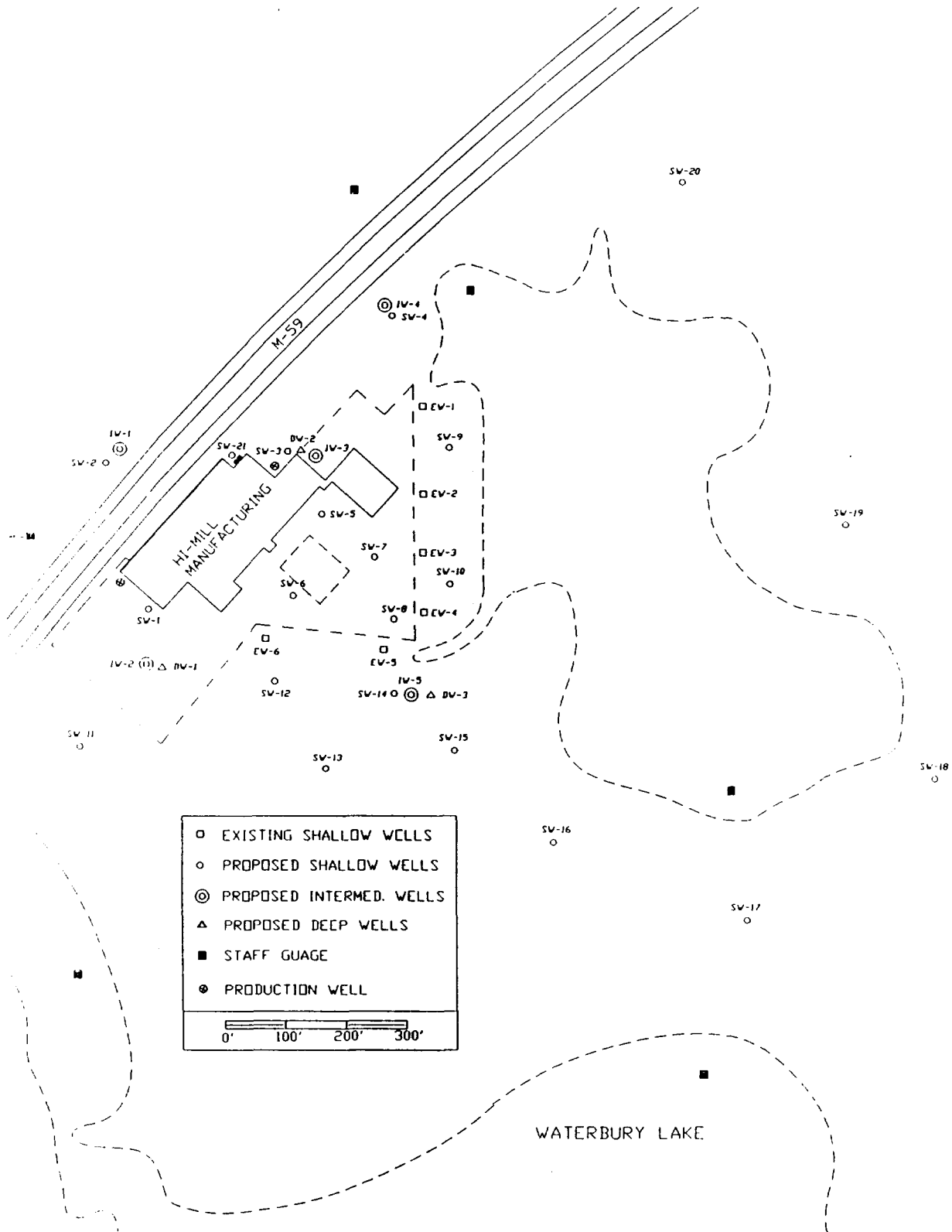
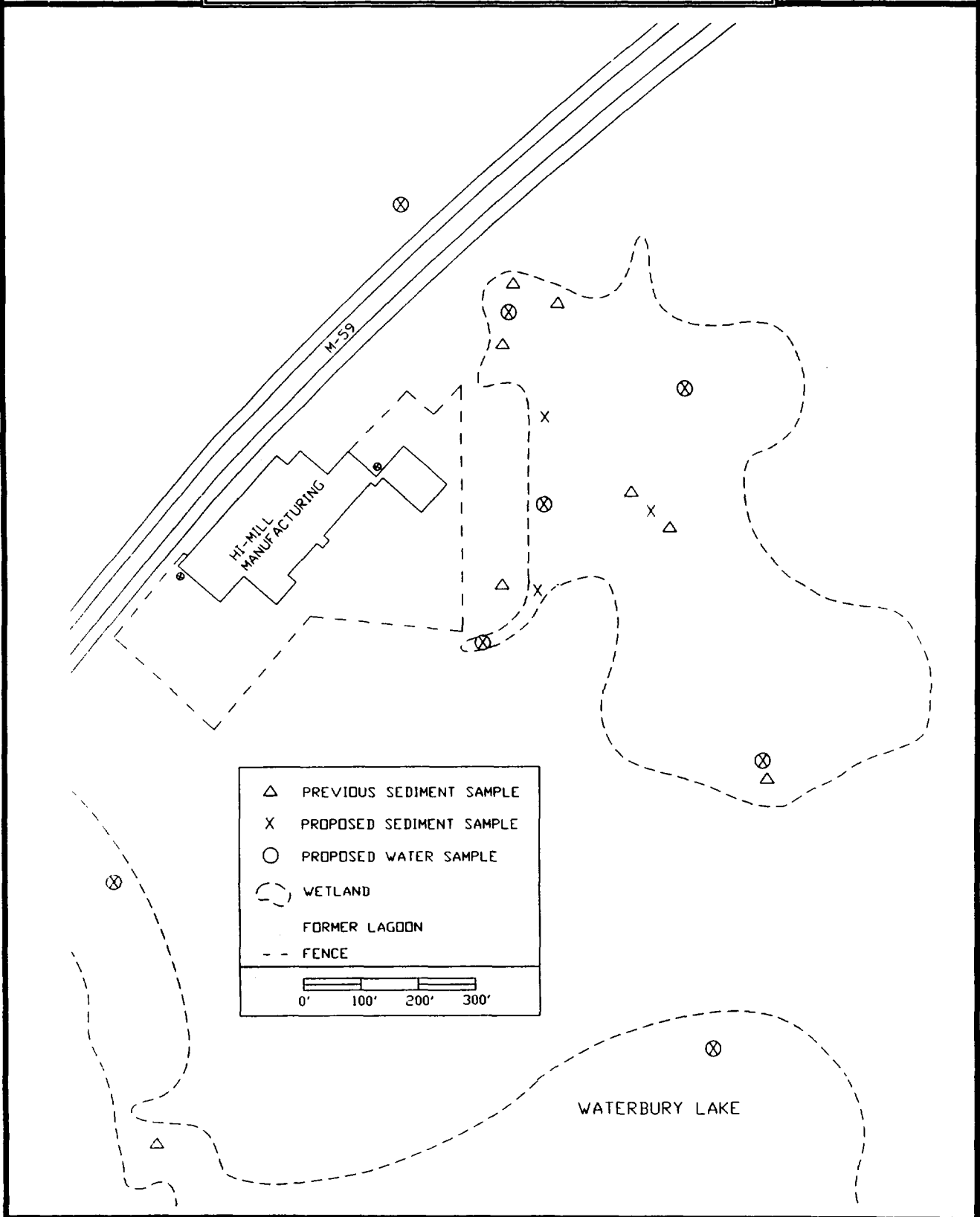


FIGURE 6-4
WETLAND SAMPLING DIAGRAM



6.4 Onsite Organization And Coordination

6.4.1 Personnel

Project Manager Dr. James Harless
Scientific Advisor Dr. James Harless
Field Team Leader Mary Adams
Site Safety Officer Sarah Burton
Project QA Officer Charles Koons

EPA Region V Representative M.E. Gustafson

DNR Representative Deborah Larsen

Contractors McDowell and Associates
(Drilling)

6.4.2 Responsibilities

Project Manager: The project Manager is the primary coordinator for all remedial investigation activities. Specifically, the Project Manager will prepare and organize all tasks, carry out personnel briefings, coordinate with the facility owners, government representatives, and subcontractors; maintain records; and compile all necessary reports.

Field Team Leader: The Field Team Leader is responsible for the on-site operation and safety of the work team. The Field Team Leader will insure that the objectives of the work plan are completed in compliance with proper control procedures; that all activities are documented properly; and that the level of protection for personnel will adequately ensure health and safety.

Site Safety Officer: The Site Safety Officer is responsible for preparing and amending the site safety plan according to the circumstances associated with the site investigation. It is the duty of the Site Safety Officer to brief all personnel as to the contents of the health and safety plan, to post emergency phone numbers and routes, enforce health and safety procedures, and monitor the work party for signs of adverse health effects. The Site Safety

Officer has the authority to halt any operation which threatens the health or safety of any member of the work team.

6.4.3 Work Party Organization

All site personnel will observe the 'buddy' system whenever present in the work zone. Two member field crews will be utilized during all drilling/sampling activities. One person will obtain and document samples while a second person will assist in field screening and monitoring.

No decontamination team will be necessary. All work party members will be briefed in the decontamination procedure and will participate in a mock decontamination exercise.

6.5 Onsite Control

6.5.1 Site Entry

The remedial investigation work zone surrounds the Hi-Mill operational facility. The facility will continue production operations throughout the remedial investigation. Therefore, site entry procedures will be arranged with the facility owners in order to limit the affect of the investigation on operations and prevent employee access to onsite work zones. The area south of the Hi-Mill facility will be marked with "No Trespassing " signs.

The area south of the Hi-Mill property line is accessible to vehicular traffic by a gravel drive which extends around the southern end of the wetland. This access drive is maintained as a part of the Highland State Recreation Area.

A log of all personnel and equipment entering the work zone shall be kept in the Field Office. All personnel will log in and out daily.

6.5.2 Control Boundaries

The work zone also extends into the Highland State Recreation Area, beyond the chainlink fence which surrounds Hi-Mill property. Public access cannot be denied in this area; therefore, work

zone boundaries will not be visually marked. Any such designation would most likely encourage interest rather than discourage entry.

The Exclusion Zone shall be designated as the area immediately surrounding the drill rig. Red barrier tape will be used to designate the Exclusion Zone. Only personnel with appropriate level of protection shall be allowed in the Exclusion Zone.

The Contamination Reduction Zone shall be designated as all remaining areas in the work zone between the Exclusion Zone and the Field Office. A decontamination station will be established near the boundary of the Exclusion Zone to reduce the possibility of transferring contaminants on personnel or equipment. See Section 6.8 for decontamination procedures.

Mark LeMay has been designated to coordinate access control and security on site. No unauthorized personnel will be allowed access into the work zone during remedial investigation activities.

6.5.3 Field Office

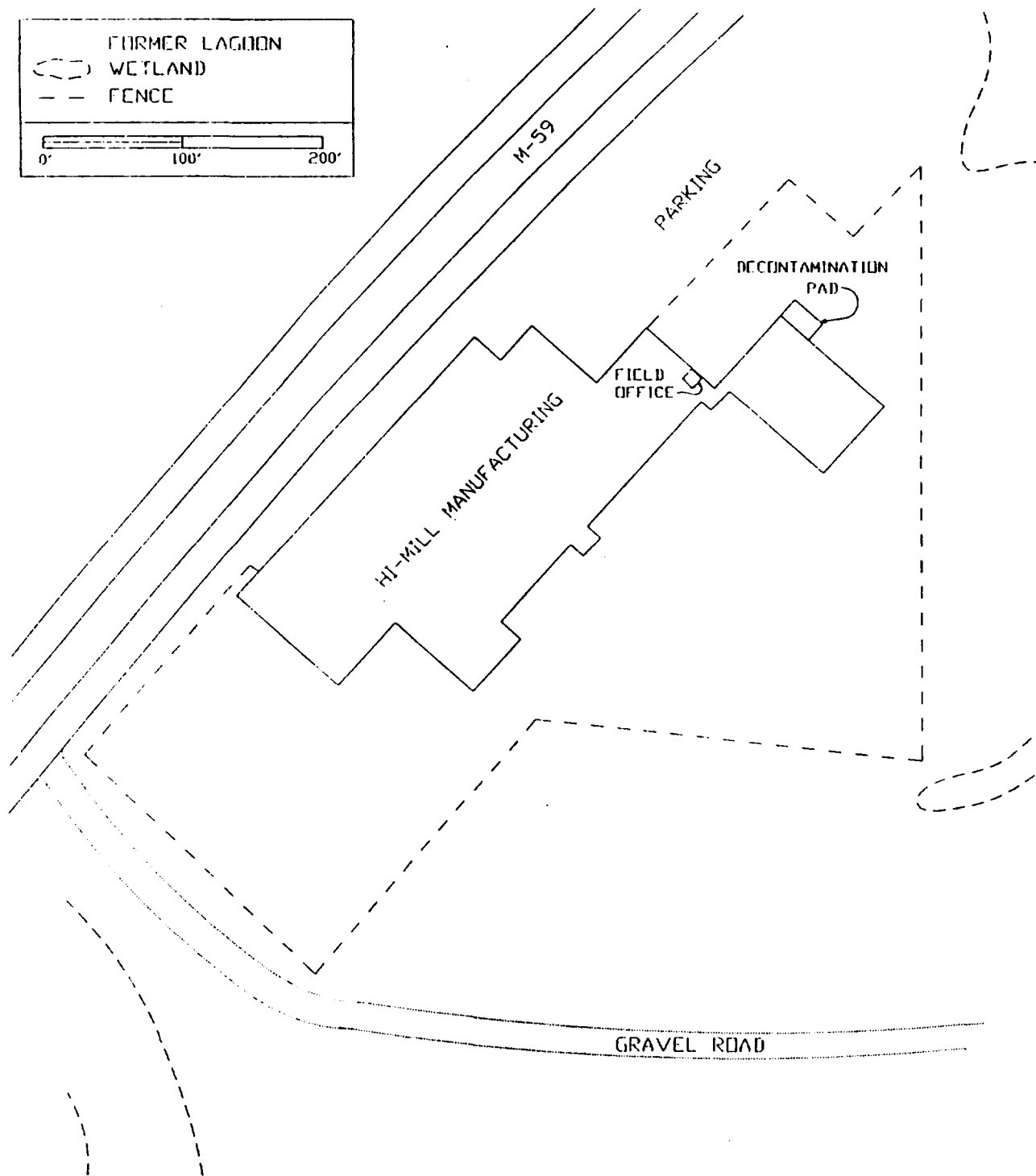
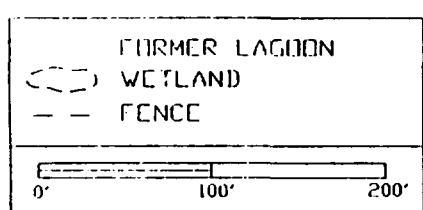
A field office and field screening area will be established within the Hi-Mill facility; this area shall be designated as a clean zone. (See Figure 6-5 for the location of onsite facilities). Hi-Mill employees will be denied access to this area. The office will contain a first aid kit and emergency eye wash solution; all personnel requiring first aid shall be removed from the work area and taken to the office. First aid kits and eye wash stations will also be located on each drilling rig and within 100 feet of each work area for immediate response to accidents.

6.5.4 Communication

Personnel in the work zone shall remain within audible range and visible sight of the Project Team Leader or Site Safety Officer. An airhorn will be kept on the drill rig at all times. Three horn blasts will be the emergency signal to indicate that all personnel should leave the work zone and report to the field office.

Telephone communication will be established with the field office as soon as possible. In addition, team members will carry handheld receiver/transmitters which will enable them to communicate with the field office.

FIGURE 6-5
SITE OPERATIONS DIAGRAM



6.5.5 Wind Direction

Variable wind direction will be indicated by wind socks attached to the drill rig. The prevailing wind for the Hi-Mill area is West-Southwest. When possible, the drill rig will be located up-wind from the decontamination station.

6.6 Hazard Evaluation

6.6.1 Chemical Hazards

The following substances are known or suspected to be on site. The primary hazards of each are identified and listed in Table 6-1.

TABLE 6-1
PRIMARY HAZARDS

<u>Substance Involved</u>	<u>Concentration (ppm)</u>		<u>TLV Levels</u>	<u>Primary Hazard (acute)</u>
Aluminum	2000*	29,200†	2 mg/cu.m	Irritant (skin, eye, lung)
Chromium	24*	5,300†	0.5 mg/cu.m	Dermatitis (skin contact) Fibrosis of Lungs (inh)
Hexavalent Chromium	Unknown	Unknown	0.05 mg/cu.m	Carcinogen, Irritant
Copper	560*	10,000†	1 mg/cu.m	Irritant (skin and eye) CNS agent (ingestion)
Zinc (as zinc oxide)	2,200*	1,800†	10 mg/cu.m	Irritant (skin, eye, lung)
Trichloroethylene	24 ppb‡		50 ppm	Acute CNS Irritant (eyes)

* Concentration in water

† Concentration in sediment

‡ Concentration in groundwater

The Threshold Limit Values (TLV) given above refer to allowable levels of contaminants in air. These values cannot be directly compared to concentrations in water or soils. Aqueous solutions demonstrate marked increases in the TLV.

Hazardous substance information forms for the involved substances have been completed and are located in Appendix E. No additional chemical hazards are expected on site.

6.6.2 Additional Hazards

The Hi-Mill site is surrounded by a natural, undeveloped area. The remedial investigation will be conducted during a time of year when wildlife will be prevalent. An attempt will be made to clear the exclusion zone of wildlife (i.e. snakes) before drilling begins. All personnel will be restricted to the work zone and not permitted to wander into uncleared areas.

6.7 Personal Protective Equipment

One of the most important aspects of health and safety on hazardous waste sites is the proper selection of personal protective equipment. The selection of personal protective equipment must be based on the potential for exposure to the known or suspected chemical hazards on site. While an inadequate level of protection may expose workers to hazardous chemicals, over protecting personnel can create an equally dangerous environment. Unnecessary protective equipment is cumbersome, often decreases efficiency and alertness, and increases fatigue.

6.7.1 Levels of Protection

The appropriateness of the level of protection will be assessed continually during all field investigation tasks.

Based on the above evaluation of potential hazards, the following levels of personal protection have been designated for the applicable work areas or tasks:

<u>Location</u>	<u>Job Function</u>	<u>Protection Level</u>
Exclusion Zone	Drilling	Level D
	Sampling	Level D
	Record Keeping	Level D
	Monitoring	Level D
<u>Location</u>	<u>Job Function</u>	<u>Protection Level</u>
Contamination	Equipment Decon.	Level D
Reduction Zone	Personnel Decon.	Level D
Field Office	Field Screening &	NONE
	Record Keeping	

Specific protective equipment for each level of protection is as follows:

Level D:

Tyvek or Saran coated Tyvek Coveralls[†]
Cotton Coveralls
Gloves (outer) Chemical Resistant (PVC or Nitrile)
Gloves (inner) Chemical Resistant (Latex)
Boots (outer) Chemical Resistant (Vinyl)
Boots (inner) Safety with Steel Toe and Shank
Safety Glasses
Hard Hat

Saran coated Tyvek will be required during the collection of water samples or during hydro-rotary drilling.

Should an upgrade to Level C protection be necessary, then NIOSH approved, full-face air purifying respirators (APRs) with HEPA/ Organic Vapor Cartridges will be utilized. All work party members will be medically cleared for for respirator use and will be fit tested and trained in the use of full-face APRs. A written respiratory protection program for the selection and use of respirators will be developed and maintained in the Field Office.

NO CHANGES TO THE SPECIFIED LEVELS OF PROTECTION SHALL BE MADE WITHOUT THE APPROVAL OF THE SITE SAFETY OFFICER AND/OR THE PROJECT TEAM LEADER.

6.7.2 Environmental Monitoring

The following air surveillance program will be employed to detect possible atmospheric contamination which may pose a health and safety hazard.

Combustible Gas Meter: All bore holes will be monitored for the presence of methane or other combustible gases and H₂S using a GasTech combustible gas meter Model GX-82. In addition, this instrument will also be utilized to indicate atmospheric oxygen deficiencies. A reading of 20% of LEL will signify "backoff". All personnel shall leave the Exclusion Zone until vapors dissipate to safe concentrations.

HNU Photolionizer: The Exclusion Zone will be monitored at constantly during all drilling or sampling activities to detect the presence of volatile organic compounds. The instrument will be calibrated specifically for trichloroethylene. A reading of 25 ppm (50% of the TLV for trichloroethylene) will signify an upgrade in the level of protection. The HNu reading will be the sum of all detectable volatile species, and the selected TLV is the lowest of the species reasonably expected to be present; therefore, this is a conservative criteria for upgrade. Personnel will immediately don full-face APRs with combination HEPA/Organic Vapor cartridges. All personnel will be aware of the warning properties associated with trichloroethylene.

Each instrument will be operated by trained personnel; instrument operation manuals will be kept in the Field Office.

6.8 Decontamination Procedures

6.8.1 Decontamination Stations

A separate area will be established close to the Exclusion Zone for equipment and personnel decontamination. A decontamination pool will be constructed using a 30 mil visqueen liner for

vehicle and large equipment decontamination. In addition, a portable pool will be set up on a visqueen sheet for sampling equipment decontamination. Any contaminated materials which are generated during the course of the remedial investigation will be collected in one of the pools. All auger cuttings, soil samples, purge water, and decontamination rinse water will be containerized in 55-gallon drums and stored as hazardous waste pending final analysis to determine proper disposal requirements. Both pools will be covered to prevent the accumulation of rain. All decontamination areas will be marked with yellow barrier tape. The standard Level D decontamination protocol will be used with the following decontamination stations:

- A) Segregated equipment drop
- B) Equipment decontamination
- C) Vehicle Decontamination
- D) Boot and glove wash
- E) Containerize wash water
- F) Remove disposable clothing
- G) Double bag disposables
- H) Containerize bags
- I) Container disposal

6.8.2 Equipment

Augers will be steam cleaned before advancing each boring. Water will be supplied by the drillers from an approved water supply. All sampling equipment (split spoons samplers, bailers, etc.) will be thoroughly rinsed with a solution of 10% nitric acid ('Instrapure Baker Analyzed' for trace metal analysis) followed by a rinse with methanol. After a final rinse with deionized water, samplers will be allowed to air dry.

Trucks and large pieces of equipment will be scrubbed with soapy water or steamed cleaned if necessary to avoid transporting material offsite.

6.8.3 Personnel

All personnel exiting from the work zone will process through a decontamination line before entering a clean zone. Emergency decontamination will include the following stations:

- A) Segregated equipment drop
- D) Boot and glove wash
- F) Remove disposable clothing

Disposable clothing will be collected, double-bagged, and containerized for proper disposal. Provisions will be made for handwashing and clothes changing onsite; however, shower facilities will not be available. All personnel will be required to shower as soon as possible after leaving the site. APRs will be inspected daily and cleaned per manufacturers instructions after each use.

6.9 Emergency Procedures

6.9.1 Emergency Phone Numbers

Police 911

Fire 911

Ambulance . . (313) 334-4901

 Fleet Ambulance Service

Hospital (313) 360-3300

 Huron Valley Hospital
 1601 Commerce Road
 Commerce Twp., MI 48042

Airport (313) 666-3900

 Oakland/ Pontiac Airport

Technical Consultant (313) 454-1100

 Techna Corporation
 44808 Helm St.
 Plymouth, MI 48170

6.9.2 Emergency Medical Care

Huron Valley Hospital, located at 1601 Commerce Road, Commerce Twp., Mi, (313) 360-3300 is located approximately 16 minutes from the site. The hospital will be contacted prior to the execution of the work plan and briefed on the situation, the potential hazards, and the hazardous substances involved. A map, including alternative routes to the facility is located in Figure 6-6 and will be available at all times at the command post.

Local ambulance service is available from Fleet Ambulance Service at (313) 384-4901. Their response time is approximately 20 minutes. If a particularly hazardous situation is foreseen, arrangements will be made for onsite standby. In addition, the Field Team Leader and the Site Safety Officer are certified in CPR.

6.9.3 Onsite Emergency Care

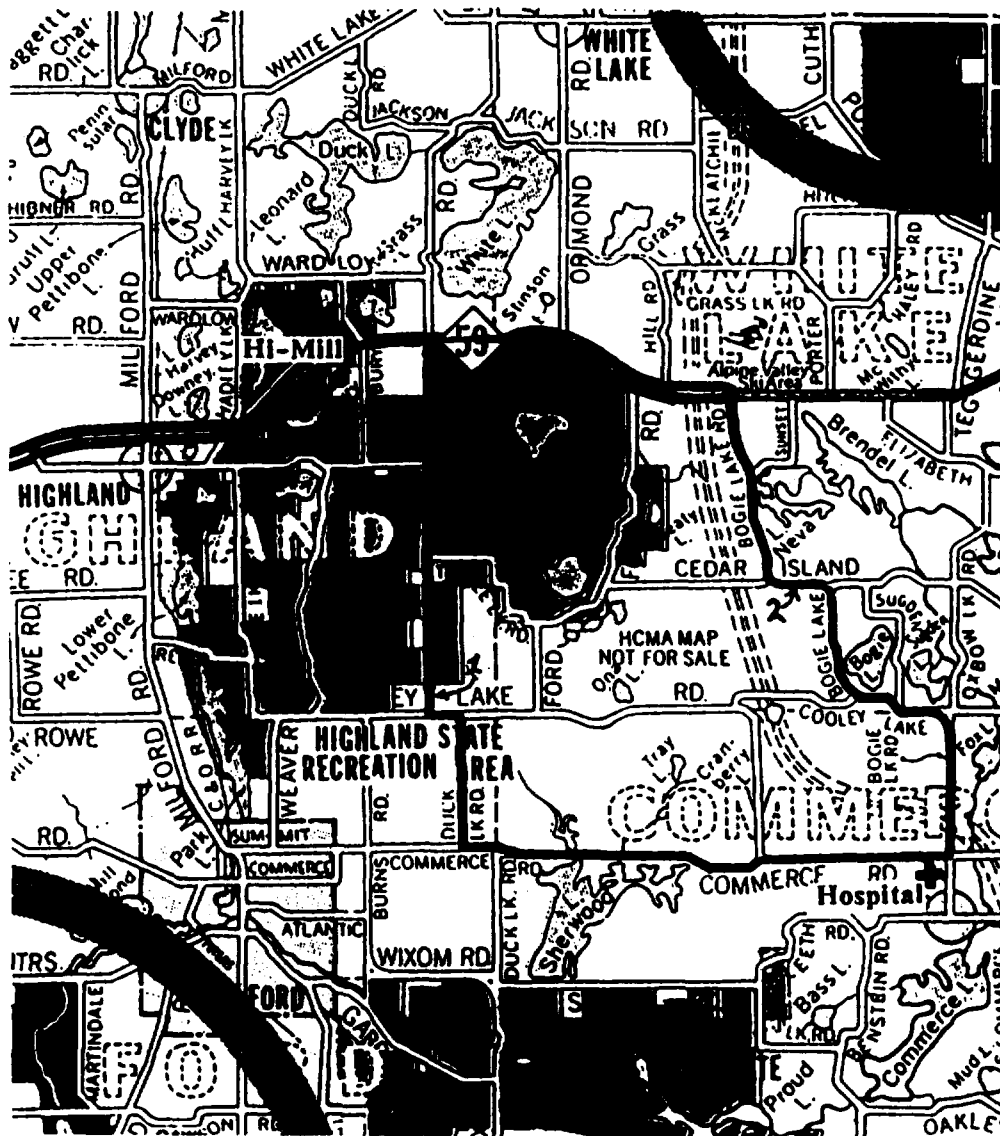
In case of accident or injury onsite, the Field Team Leader and/or the Site Safety Officer shall be notified immediately. Appropriate first aid response should be initiated immediately. The following emergency response equipment will be located onsite:

First-aid Kit	Field Office, Drill Rigs
First-aid Manual	Field Office
Emergency eye wash	Field Office, Drill Rigs

Emergency information for the substances present is available on the chemical Evaluation Sheets located in Appendix I.

If the injury requires additional medical attention, the Field Team Leader or Site Safety Officer shall immediately arrange transportation to the most appropriate medical care facility.

FIGURE 6-6
HOSPITAL EMERGENCY ROUTES



ROUTE 1: East on M-59 to Duck Lake Rd. (second intersection)
Right on Duck Lake to Cooley Lake Rd. (appr. 2 miles)
Left on Cooley Lake then Right again on Duck Lake
Left on Commerce Rd.
Hospital is on the Right side of the road (appr. 4 miles)

ROUTE 2: (No dirt roads)
Take M-59 East to Bogie Lake Rd. (appr. 3 miles)
Right on Bogie Lake Rd.
Follow Bogie Lake to Commerce
Right on Commerce
Hospital is on the Left side of the road.
First-aid equipment is available on-site at the following locations:

6.9.4 Specific Procedures

The following standard emergency procedures will be used by on-site personnel. The Site Safety Officer shall be notified of ANY on-site emergency or accident and will be responsible for ensuring that the appropriate procedures are followed.

Personnel Injury in the work zone:

Upon notification of an injury in the work zone, the emergency horn will be sounded three times. If possible, the injured person should be decontaminated and moved to the field office for first aid. The Site Safety Officer and the Project Team Leader should evaluate the nature of the injury, and determine if further medical attention is necessary.

If necessary, rescue personnel may enter the Exclusion Zone to initiate first aid. Contact will be made with an ambulance service for transportation to the designated medical facility. No persons shall reenter the Exclusion Zone until the cause of the injury or symptoms is determined.

Fire/Explosion:

Due to the nature of the hazards associated with the Hi-Mill site, there is a low probability of fire or explosion. However, a hand held fire extinguisher will be kept on the drill rig at all times. If the fire threatens any of the areas of the Highland State Recreation Area or the Hi-Mill Manufacturing facility, the Fire Department will be summoned immediately. The emergency horn will be sounded three times and all site personnel will assemble at the field office.

Personal Protective Equipment Failure:

If any site worker experiences a failure or alteration of protective equipment that affects the protection factor, that person and his/her buddy shall immediately leave the Exclusion Zone and proceed through the decontamination line. Reentry shall not be permitted until the equipment has been repaired or replaced.

Other Equipment Failure:

If any other equipment on site fails to operate properly, the Project Team Leader and the Site Safety Officer shall be notified. They will then determine the effect of this failure on continuing operations on site. If the failure affects the safety of personnel or prevents the completion of the Work Plan tasks, all personnel shall leave the work zone until the situation is evaluated and the appropriate actions taken.

In all situations, when an onsite emergency results in the evacuation of the work zone, personnel shall not reenter until:

1. The conditions resulting in the emergency have been corrected.
2. The hazards have been reassessed.
3. The Site Safety Plan has been reviewed.
4. Site personnel have been briefed on any changes in the Site Safety Plan.

6.10 Plan Distribution and Familiarity

All site personnel have participated in an employer approved Health and Safety Program. The program includes employment entry and exit physicals, a medical evaluation of the ability to wear respiratory protective equipment, annual monitoring examinations, and hazardous site safety training as required under 29 CFR Part 1910. All site personnel will be required to present proof to the Site Safety Officer that the above training and medical monitoring specifications have been met.

All site personnel have been provided with a copy of this Health and Safety Plan and have been briefed as to its contents. Contractors have been given additional copies and are responsible for providing any additional employees with copies of the plan and other safety information. Any revisions to the plan must first be reviewed by the Field Team Leader and the Site Safety Officer. A copy of this plan, including all revisions, will be posted in the Field Office throughout the duration of the remedial investigation.

A signature below acknowledges that site personnel have read the above plan and are familiar with its provisions.

NAME _____

SIGNATURE

Site Safety Officer

Project Team Leader

Other Site Personnel

7.0 PERMITTING REQUIREMENTS PLAN

Permitting requirements in the Hi-Mill RI will result from activities on property not owned by Hi-Mill, the installation of monitoring wells >25' deep, and the generation and disposal of solid wastes.

7.1 Off-site Activities

Soil boring/sampling, surface water and sediment sampling and groundwater monitoring well installation activities are scheduled to be conducted on property not owned by Hi-Mill Manufacturing Company. Access to the Highland State Recreation Area and other state-owned lands will be required. Access to land owned by the Michigan Department of Transportation and private parties may be required for investigative activities and/or access to property where such activities are to be conducted.

Specific permit/agreement needs will be identified prior to implementation of RI activities. All permits, access agreements and easements necessary to perform the off-site components of the RI will be promptly requested. Acquisition of all permits, easements and access agreements will be the responsibility of Hi-Mill Manufacturing Company in accordance with the terms and conditions of the consent order.

7.2 Monitoring Well Permits

The Michigan Mineral Well Act requires that all wells installed to a depth of $\geq 25'$ must be permitted by the Michigan Department of Natural Resources. Techna will obtain the necessary damage bond prior to monitoring well installation and will submit the required permit application and supporting documentation after all wells have been installed.

7.3 Waste Management

Sampling and decontamination activities during the RI will generate solid wastes that may be hazardous or non-hazardous according to the Michigan Hazardous Waste Management Act (Act 64) rules. These waste will be evaluated to determine the proper waste classifications and disposal methods and sites. All wastes will be properly contained, labeled and stored while on-site. Hi-Mill is a registered generator (MID005341714) of hazardous wastes and will be the generator of record for all wastes collected during the RI.

All waste materials will be transported by a licensed transporter to a properly licensed industrial or hazardous waste treatment or disposal facility. The selection of appropriate licensed transporters and disposal sites will be the responsibility of Techna Corporation acting on behalf of Hi-Mill.

SECTION 8.0
QUALITY ASSURANCE PROJECT PLAN
REMEDIAL INVESTIGATION/FEASIBILITY STUDY
HI-MILL MANUFACTURING COMPANY
Highland, Michigan

Prepared by:

TECHNA CORPORATION
44808 Helm Street
Plymouth, Michigan 48170

Approved by:

Project Manager
TECHNA CORPORATION

James M. Harless

Date

Quality Assurance Officer
TECHNA CORPORATION

Charles F. Koons

Date

Quality Assurance Officer
USEPA Region V

Date

Remedial Project Coordinator
USEPA Region V

Mary Elaine Gustafson

Date

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**REMEDIAL INVESTIGATION/FEASIBILITY STUDY
HI-MILL MANUFACTURING COMPANY
HIGHLAND, MICHIGAN**

8.0 QUALITY ASSURANCE PROJECT PLAN

Subsections 8.1.1 through 8.1.5 of this section reflect the opinions of Hi-Mill Manufacturing Company. The USEPA does not admit to the facts or conclusions contained in subsections 8.1.1 through 8.1.5. Attachments included in Appendix A of this workplan are for information only and are not hereby incorporated or made part of the consent agreement between Hi-Mill Manufacturing Company and the USEPA.

8.1 Project Description

The following subsections describe the location and plant operations history of Hi-Mill Manufacturing Company and the geology, hydrology and ecology of the plant site and surrounding areas. Summaries of previous contamination assessment and control activities, an overview of RI project tasks, intended data usage, and the RI project schedule are also presented.

8.1.1 Location and Description

The Hi-Mill plant is located in southeastern Michigan in Highland Township, Oakland County, approximately 1.5 miles east of the town of Highland (Figure 8-1). The plant address is 1704 Highland Road (M-59) which is located within Section 23, T7N R18W. The site occupies an irregularly shaped property of approximately 4.5 acres in size (Figures 8-2, 8-3 and 8-3A) which lies at an elevation of approximately 1010 feet above mean sea level.

The Hi-Mill building and parking area occupy most of the site. The building lies in the northwest part of the property and is irregularly shaped, having been expanded several times since its original construction in 1946. It houses the corporate and administrative offices, tubing production facilities and raw material storage and preparation areas. Paved parking areas occupy all of the property northeast of the production/office building and part of the site southwest of the building. The remainder of the property is covered with vegetation.

FIGURE 8-1
LOCATION MAP

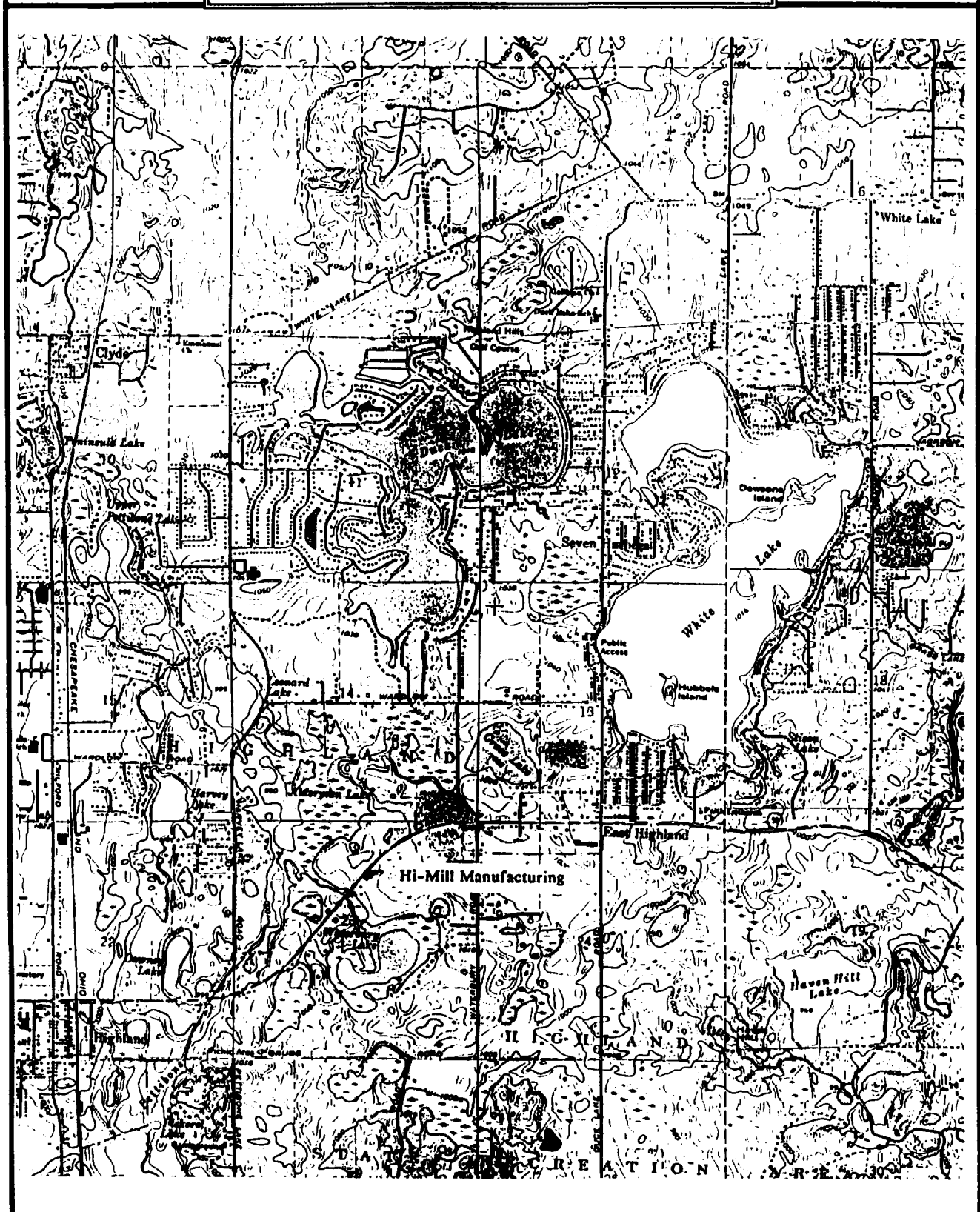
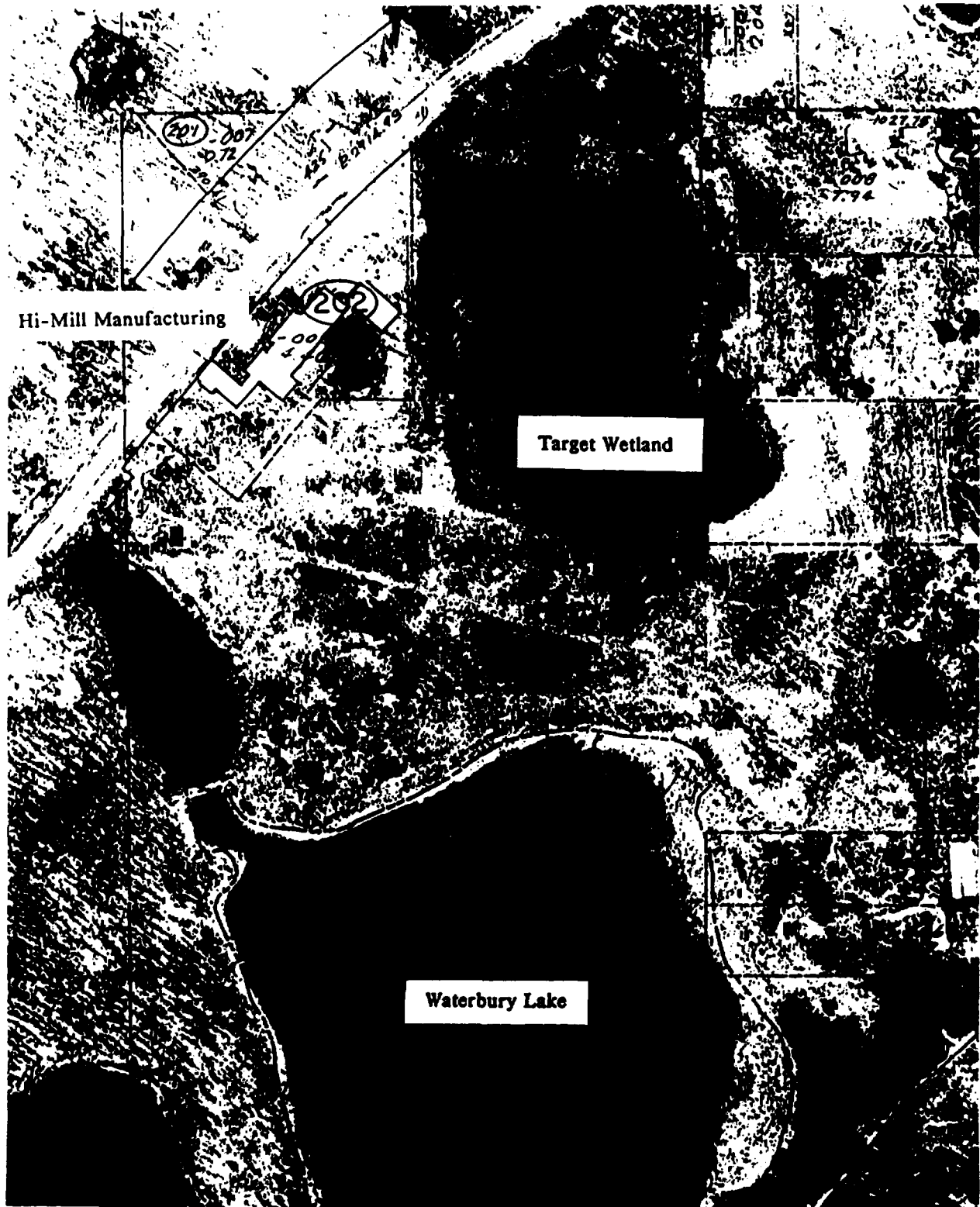


FIGURE 8-2
1980 AERIAL PHOTO



The site is bounded to the northwest by Highland Road (M-59), a four lane, divided highway. It is bounded on all other sides by the Highland State Recreation Area, which is owned and maintained by the Michigan Department of Natural Resources. Specifically, the Hi-Mill site is bounded to the east by a marsh/pond of approximately 8 - 10 acres in size. The site is bounded to the south by a slightly elevated, vegetated plain and woodlands area. Waterbury Lake lies approximately 900 - 1000 feet south of the site. The immediate area around Hi-Mill is sparsely populated and rural in nature. The nearest dwellings lie approximately 2000 feet east and southeast of the site, along Waterbury Road. No other manufacturing or commercial facilities are located within 1000' of the Hi-Mill site.

Highland Township is a rural/suburban area with a population of approximately 17,000 - 19,000. The rural/suburban nature of the township is reflected in the lack of large population or commercial centers and the absence of many city services. A majority of inhabitants obtain drinking water from domestic water wells and dispose of sewage through individual septic systems.

Hi-Mill Manufacturing obtains process and drinking water from two water wells located on the property (Figure 8-3). One well, lying immediately west of the production building, is set at 50' below grade, and the other, lying immediately east of the production building is set at a depth of 89'. Sanitary sewage is disposed through a septic system.

8.1.2 Plant Operations History

Since its formation in 1946, Hi-Mill Manufacturing Company has fabricated copper, aluminum and brass tubing parts and fittings. Production operations have included cutting, machining, forming, shaping and soldering of the raw tubing and fabricated tubing components. Support operations have included nitric and sulfuric acid cleaning and brightening, chromic acid washing, and degreasing.

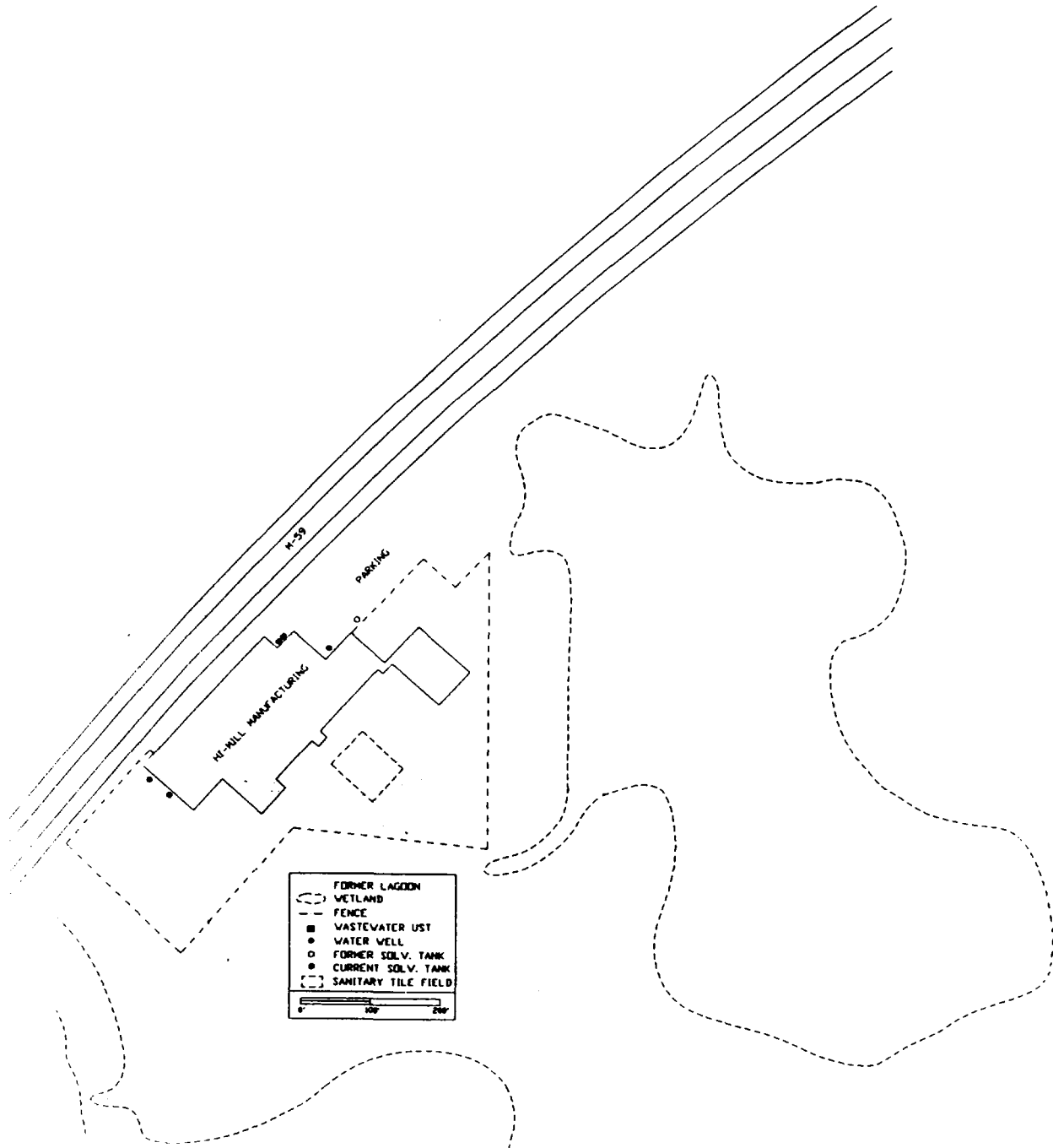
Aspects of Hi-Mill's historical plant operations which are pertinent to this RI/FS program are described below.

Wastewater Discharges

From prior to 1960 (exact date unknown) to 1981 process wastewaters were discharged to an unlined lagoon located southeast of the main production building (Figures 8-3 and 8-3A). The lagoon was approximately 60 - 80 feet in diameter, and the base of the lagoon was excavated

FIGURE 8-3

SITE PLAN



six feet into the underlying clay stratum. This stratum consists of extremely stiff clay and is approximately 35 feet thick. The sides and retaining walls of the lagoon were constructed of fill dirt and indigenous sandy clays.

Process wastewaters consisting primarily of spent acid brightening solutions and rinse waters were discharged to the lagoon. Reduction of water volumes in the lagoons occurred mainly through evaporation and seepage.

In 1975 Hi-Mill applied for and received a groundwater discharge permit (M00167, October 31, 1975) for the lagoon from the Water Quality Division of the Michigan Department of Natural resources (MDNR). In the Fall of 1976, Hi-Mill constructed a second, smaller lagoon south of the original lagoon (Figures 8-3 and 8-3A). This second lagoon received overflow waters from the original lagoon.

In December 1976 and November 1977, direct overflows of the second lagoon to the nearby marsh were observed by MDNR staff. The company was then requested by the MDNR to apply for an NPDES permit for the discharges. A proposed permit was issued by the MDNR on September 16, 1977, but the USEPA refused to concur with the issuance of the permit. In December 1977 Hi-Mill agreed to design and implement a wastewater recycle system and cease discharging to the lagoons.

The wastewater recycle system was fully operational in 1981, and subsequent discharges to the lagoons were terminated. Between 1981 and 1983 Hi-Mill attempted to evaporate the water remaining in the lagoons by intermittently discharging it through spray nozzles attached to the roof of the production building and to portions of the eight-foot high fence that surrounds the rear (south) of the site.

All process wastewater that could not be recycled was pumped to an underground, concrete wastewater holding tank (Figure 8-3A) located in front of the northeast part of the production building. When this tank became full, the wastewater was transported by a licensed waste transporter to a permitted hazardous waste treatment facility. This waste management system is still operative.

In September 1983 Hi-Mill requested permission from the MDNR to remove the sludge from the large lagoon, excavate surrounding soils, and backfill the area with clean fill. This was accomplished in November and December 1983 by General Oil Company of Livonia, Michigan. Contaminated soils were removed from the sides and bottom of the large lagoon, and then an additional one foot of clay was excavated from the bottom to ensure removal of all contaminated soils. Excavated sludges and soils were transported and properly disposed off-site by landfilling.

All activities were monitored by representatives of the MDNR, and the excavated site was inspected by the MDNR prior to backfilling. The fate of the smaller, overflow lagoon is unknown.

Hi-Mill terminated all pickling and chromic acid washing activities in the Fall of 1988. Therefore, metals-contaminated wastewaters are no longer being generated.

Degreasing Operations

Degreasing of fabricated tubular parts has been a part of Hi-Mill's process since prior to 1970. Trichloroethylene was received and stored in an aboveground tank located approximately 50' east of the production building, and the east water well (Figure 8-3A). Solvent was transferred to the degreasing equipment inside the plant via piping. In 1986 a second trichloroethylene storage tank was constructed in a diked containment (Figure 8-3A) area immediately west of the production building, approximately 20 - 30 south of the west water well. In the Summer of 1988, the original, east tank and associated piping were removed and disposed.

8.1.3 Geology, Hydrology and Ecology

General Regional Geology

Surface topography and associated soil deposits in this region of Southeastern Michigan result from glacial processes occurring during the Wisconsin Glacial Stage of the Pleistocene Series. Glacial action has deposited a mantle of glacial debris (soil), ranging in thickness from 225 feet to more than 300 feet. The stratigraphy of the glacial deposit is quite complex and represents materials deposited during successive advancements and retreats of the ice front(s).

The surface topography of the region is generally representative of the interlobate morainic system which lies on a northeast-southwest axis extending from approximately Jackson to Oxford. This morainic system results from interaction of the Saginaw, Huron and Erie Lobes. The Saginaw lobe advanced from the northwest, joining the Huron Lobe which advanced from the northeast and the Erie Lobe which advanced from the east.

Surface formations within the study area were formed primarily during retreat of these glacial ice lobes with the subsequent meltwater influencing much of the topography and near-surface soil deposits. Much of the area contains outwash material at the surface, deposited by glacial meltwaters.

Many closed depressions (kettles) dot the outwash sediments. These formed as a result of large blocks of ice, left behind by the rapidly receding glacier front, which were surrounded and covered by outwash sediments. As the buried or partially buried ice blocks melted, the sediments slumped into the resultant voids. This phenomenon is responsible for the pitted outwash topography evident in the study area. Kettles serve as basins for the numerous lakes and swamps found throughout the region.

The subsurface stratigraphy in the region is complex and is representative of variable climatic conditions throughout the period of glaciation. Soils encountered within the profile may be well-sorted granular materials representative of a period of rapid melting, lacustrine clay indicating the presence of a lake near the ice margin, ground moraines indicating a period of ice advance, as well as buried recessional moraines. Therefore, throughout most of the area, the general stratigraphy of the glacial deposits consists of regionally discontinuous interbedded layers of lacustrine clay, unsorted moraines and outwash deposits.

In general, the region can be characterized as having well defined surface moraines with moderate permeability, ground laid moraines and lacustrine clays with low permeability and outwash deposits ranging from moderate to high permeability. Where present, the finer grained soils serve as an aquaclude that provides a bottom seal for an unconfined surface aquifer. The clay aquacludes also serve as the top confining seal for some artesian aquifers within the general region.

Mississippian age Coldwater Shale underlies the glacial soil at estimated depths of 225 to approximately 300 feet.

Regional Groundwater

The thick, glacial drift (including outwash) coupled with the relatively impermeable (sometimes interbedded) till clay and underlying shale bedrock form a major groundwater reservoir. Surface deposits of sand and gravel outwash which are encountered throughout most of the area are very permeable. The morainic ridges are generally predominantly granular and moderately permeable with only a thin, discontinuous clay cap. The absorbent nature of the outwash and some morainic deposits is indicated by the lack of large scale water erosion and the rapid infiltration of precipitation falling upon them. The many lakes and swamps that dot the region are surface expressions of the water table. The entire area underlying this region is an excellent catchment basin and storage reservoir for groundwater.

In the immediate vicinity of the site, it appears that a relatively continuous zone of low permeability soil underlies the granular outwash encountered locally at the surface. This conclusion is based on the presence of clay soil within the most recent series of borings coupled with the presence of the well developed natural drainage feature leading from Waterbury Lake and the well defined channel occupied by Pettibone Creek.

A major groundwater divide roughly corresponding to the topographic watershed divide is located somewhat northwest of the site under consideration. The direction of regional groundwater flow is nominally toward the southeast, and in the immediate vicinity of the subject site, groundwater flow direction is also toward the southeast.

This region serves as the principal groundwater intake or recharge area for the buried sands and gravels of the glacial lake plain region located in parts of Royal Oak, Southfield, Troy, Avon, Bloomfield and Farmington Townships, in Oakland County.

Local Surface and Groundwater Conditions

The site is within a relatively complex surface outwash area which provided drainage from meltwaters originating in the vicinity of Duck and White Lakes to the north and northeast of the site as well as meltwater originating from Waterbury Lake and higher ground to the south. It is apparent that meltwater originating in the immediate vicinity of the Hi-Mill facility generally flowed northerly toward Alderman Lake and then southerly into Pettibone Creek.

The Hi-Mill facility is bordered by M-59 and a horseshoe shaped wetland area which is partially occupied by Waterbury Lake (south of the facility). The wetland area is interrupted by a low ridge which separates the pond and wetland lying east of the facility from the larger wetland occupied by Waterbury Lake.

Based on the results of test borings performed in the area, it is apparent that the wetland area is a reflection of an unconfined surface aquifer residing in a relatively thin veneer of outwash soil. The underlying clay stratum disclosed in recent the borings (Section 8.1.4) serves as a barrier between the upper aquifer and a deeper, confined aquifer which has a different piezometric head (Section 8.1.4).

The surface and subsurface conditions observed at the site suggest that contaminants entering the western portion of the wetland zone east of Hi-Mill most likely would be predominantly isolated within that portion of the wetland.

General Environment

The area surrounding the Hi-Mill facility is a valued habitat, much of which has been acquired by the Michigan Department of Natural Resources for inclusion in the Highland State Recreation Area. Due to the varied topography, including the presence of wetlands, the region provides important habitat for wildlife under increasing pressures from urbanization/development along the M-59 corridor.

The fishery resources in the area consist of warmwater populations in the larger lakes and in Pettibone Creek. It appears unlikely that Waterbury Lake represents a particularly viable fishery resource, as it has a maximum depth of only approximately 5-feet. There is, however, no current information regarding and inventory of the lake's inhabitants. The pond located east of Hi-Mill is even less likely to be a viable fishery due to its low and variable water levels.

The majority of the land in the immediate vicinity of the site is unmanaged with respect to vegetation. Where present (south of Waterbury Lake), abandoned farmland is reverting to a more natural state. The area supports a variety of plant species ranging from oak and maple stands on the forested upland areas to swamp forests, shrubby swamps of willow and dogwood and marshes containing cattails, reptiles, and bird species.

8.1.4 Previous Contamination Assessment and Control Activities

Seven contamination identification, assessment and/or control projects have been conducted at the Hi-Mill site to date. The activities and results of the projects are summarized below. Copies of reports discussed below are included in Appendix A.

Pre-1978 - MDNR Data

In April 1972 the MDNR staff investigated an employee complaint that the plant water wells might be contaminated. Samples of the groundwater from the two wells and surface water from the marsh were collected and analyzed. "Slightly elevated" (no comparison standard was presented) levels of copper (0.38 mg/l) were measured in one well, and elevated levels of copper and nitrates were measured in the marsh waters located immediately adjacent to the Hi-Mill property.

The MDNR collected additional samples of the marsh water on October 9, 1975. Analyses of these samples indicated elevated levels of copper, aluminum, zinc, chromium, and nitrates.

In May, November and December 1976, MDNR personnel collected and analyzed samples of the wastewaters contained in the two ponds. The mean concentrations of the parameters measured in these samples are presented below:

<u>Parameter</u>	<u>Concentration (mg/l)</u>
Copper	5.23
Aluminum	24.50
Chromium (total)	1.29
Chromium (hexavalent)	0.28
Nickel	0.02
pH	5.08
N (NH ₃)	13.67
N (NO ₂)	0.42
N (NO ₃)	59.67

Based on available data, there is no indication that background or QA/QC samples were collected or analyzed to validate the data collected in any of these early studies.

April 1978 - MDNR Study of Adjoining Marsh Area

In April 1976, staff of the MDNR Water Quality Division undertook a study of the soils and sediments in the marsh, water in the lagoon, and groundwater from one of Hi-Mill's water wells to assess contamination potential. The well selected for sampling was the one identified in the 1972 study as having elevated levels of copper. Background sediment samples were collected from Pontiac Lake.

The chemical analysis results indicated no metals contamination in the Hi-Mill water well sample. Elevated levels of nitrate, nitrite, ammonia, copper, zinc and aluminum were measured in water samples from the lagoon and marsh waters immediately adjacent to the Hi-Mill property. Since no background samples were analyzed, it is not clear if results from a mid-marsh sample is reflect normal or elevated levels of chemical species measured.

Elevated levels of total chromium, copper and aluminum were measured in sediment samples collected from the lagoon and marsh. Slightly elevated levels of lead and zinc were also reported. No nickel contamination was reported.

August 1982 - MDNR Hydrogeological Study

In August 1982 the MDNR Water Quality Division performed a hydrogeological study at the Hi-Mill plant site. This study consisted of the installation of six, shallow groundwater monitoring wells along the east and south property lines (adjacent to the Highland State Recreation Area), measurement of groundwater elevations, and sampling and analysis of groundwater samples. The monitoring wells were set at depths of 4' - 7' below grade in saturated surficial clayey soils of low permeability (MDNR conclusion based on soil type and well recharge time).

The flow of the perched water was determined to be generally in a southeasterly direction toward to marsh. Elevated levels (2 - 10 times background) of copper, chromium (total), zinc and aluminum were found in samples from monitoring wells located east and southeast of the lagoon. Concentrations of lead and nickel were found not to be above background levels.

November 1983 - Removal of Lagoons

In September 1983 Hi-Mill requested permission from the MDNR to remove the sludge from the large lagoon, excavate surrounding soils, and backfill the area with clean fill. This was accomplished in November and December 1983 by General Oil Company of Livonia, Michigan. Contaminated soils were removed from the sides and bottom of the lagoon, and then an additional one foot of clay was excavated from the bottom of the lagoon to ensure removal of all contaminated soils. Excavated sludges and soils were transported and properly disposed off-site in a licensed landfill. All activities were monitored by representatives of the MDNR, and the excavated site was inspected by the MDNR prior to backfilling. The fate of the small, overflow lagoon is unknown.

April 1984 - MDNR Biological, Surface Water and Sediment Survey

In April 1984 personnel of the MDNR Surface Water Quality Division performed a limited biological, surface water and sediment survey of the marsh east of Hi-Mill, of Hi-Mill's roof and parking lot run-off areas and of the nearby Waterbury Lake. Water and sediment samples were collected and analyzed for aluminum, arsenic, iron, mercury, zinc, cadmium, chromium (total), copper, nickel and lead. Benthic and phytoplankton organisms were collected and identified visually on-site and by laboratory microscopy.

The chemical analyses of water samples indicated that concentrations of zinc, chromium and copper in marsh waters were lower than those measured in 1978, but still elevated in comparison to the background samples collected from Waterbury Lake. The levels of chromium and zinc did not exceed freshwater aquatic life criteria, but the levels of copper (50 - 200 $\mu\text{g/l}$) exceeded the chronic criteria (33 $\mu\text{g/l}$) for warm water fish. Elevated levels of copper, zinc, chromium and aluminum were also found in the run-off from the roof drainage and parking lot; the levels of copper in these samples exceeded the acute and chronic criteria for aquatic life.

Elevated levels (2 - 100 times those in sediments from Waterbury Lake) of aluminum, zinc, chromium (total), and copper were measured in sediments from the marsh and from parking lot and roof run-off drainage areas. Levels of arsenic, mercury, cadmium, nickel and lead were not found to be significantly different from the levels in Waterbury Lake samples.

The biological survey revealed few benthic or other bottom-dwelling organisms. Insufficient data were available to determine if this was a result of the significant marsh water level fluctuations or from metals contamination. Zooplankton were present at both sampling stations in the marsh. Daphnia sp., a copper sensitive organism, were abundant at the marsh sampling station where copper concentrations in the water were highest. The presence of a variety of filamentous green algae, flagellates, other algae and macrophytes indicated that the contamination did not have much impact on these aquatic plants.

The MDNR report noted that the limited visual and chemical analysis data collected during this survey supported the conclusion that Waterbury Lake had not been impacted by Hi-Mill's surface water discharges at that time (1984).

April - October 1987 - Numatics, Inc. Discharge Permit Data

Numatics, Inc. has been discharging wastewaters from metal finishing rinse tanks to a drain tile field under a MDNR groundwater discharge permit. In response to Numatics' most recent application to renew the discharge permit, the MDNR required a soils and groundwater assessment to determine if past discharge practices had negatively impacted the environment. The result of the soils investigation in the area of the drain field indicated that elevated levels of chromium and hexavalent chromium had accumulated in subsurface soils. Data from one round of samples from groundwater monitoring wells did not reveal significant levels of pollutants. The groundwater flow direction was determined to be southwest toward the wetland pond east and south of Hi-Mill.

March - November 1988 - Oakland County Health Department Process Well Survey

The Oakland County Health Department and the Michigan State Department of Health sampled and analyzed water samples from Hi-Mill's two production water wells seven times during the period March 22, 1988 through November 2, 1988. Initially, samples were analyzed for water quality parameters, trace metals and volatile solvents; later analyses were confined to volatile solvents. All samples were analyzed by the Michigan Department of Health laboratories in Lansing, Michigan. No field or trip blanks were analyzed, and no laboratory quality assurance data is available to assess the validity of results.

All samples were found to contain "not detected" or acceptable levels of metals and other water quality parameters. The sample from March 1988 (composite of the two wells) was found to contain 41 $\mu\text{g/l}$ trihalomethanes and 1 $\mu\text{g/l}$ (method detection limit) benzene; the trihalomethanes have not been detected in subsequent samples and were probably sampling or analysis artifacts.

No volatile organics were measured in a June 29, 1988 composite sample.

On July 14, 1988, trichloroethylene was measured at 1 $\mu\text{g/l}$ (method detection limit) in the west well, and benzene was measured at 4 $\mu\text{g/l}$ in the east well; benzene has not been detected in subsequent samples and was probably a sampling or analysis artifact.

No organics were identified in a composite sample collected on September 1, 1988.

Another set of samples was collected on October 4, 1988; trichloroethylene was measured in both the east and west wells (3 $\mu\text{g/l}$ and 24 $\mu\text{g/l}$ respectively), and cis-1,2-dichloroethylene was measured (2 $\mu\text{g/l}$) in the west well.

Analyses of samples collected on October 12, 1988 indicated the presence of trichloroethylene and cis-1,2-dichloroethylene in the west well at levels of 3 $\mu\text{g/l}$ and 2 $\mu\text{g/l}$ respectively. Trichloroethylene was measured in the east well at 12 $\mu\text{g/l}$.

A sample collected from the west well on November 11, 1988 was found to contain 7 $\mu\text{g/l}$ trichloroethylene and 2 $\mu\text{g/l}$ cis-1,2-dichloroethylene. The sample from the east well was found to contain 3 $\mu\text{g/l}$ trichloroethylene.

The Michigan Department of Health notified Hi-Mill on November 7, 1988 that the analysis results indicated that the water from the process wells was not acceptable for human consumption.

Hi-Mill was instructed to warn employees not to drink the water, to provide bottled drinking water, abandon both existing wells, and to install a new well to provide potable water to the facility.

November 1988 - Techna Corporation Hydrogeological Study

Techna designed and implemented a limited hydrogeological assessment of the Hi-Mill site in November 1988 in response to the findings of chlorinated solvents in the Hi-Mill process wells. Previous available data from the August 1982 MDNR indicated that the site is underlain by stiff clay, and data from non-MDNR well logs prepared by drinking water well installation contractors indicated the the clay is 25' - 45' thick. If this were true, the presence of chlorinated solvents in two wells, laterally separated by a distance of almost 300', would be difficult to explain based on typical soil migration mechanisms. Furthermore, the well screens are located at significantly different depths, 89' below grade for the east well and 50' below grade for the west well. This could imply that two different aquifers were affected.

Techna designed the hydrogeological program to accomplish the following objectives:

- determine subsurface stratigraphy to a depth of approximately 100';
- sample and analyze groundwater samples to determine extent of possible solvent contamination;
- determine approximate direction of groundwater flow in the deeper aquifer(s);
- evaluate connectivity between multiple, deeper saturated zones if any were found; and
- evaluate the potential for contaminants in surficial saturated zones near the process wells.

Three boreholes were advanced at the Hi-Mill site to an approximate depth of 100' below the existing ground surface. Boreholes were placed at the northeast corner of the property, at the west corner of the property, and south of the production building in the area of the former lagoon. Soil types were logged during the drilling operations, and temporary, 2" diameter PVC monitoring wells were placed in each location.

The general subsurface stratigraphy at the site consists of 1.5' - 3' of fill underlain by 26' - 45' of stiff, moist, silty blue clay. This layer was contiguous in the northeast and south borings; however, in the west boring a layer (5' \pm 2') of fine silty sand was found in the clay stratum between the depths of 12' and 17', and a compact sandy silt layer (3' \pm 1') was found between the depths of 24' and 27'.

In the northeast borehole, a wet sand stratum was encountered between the depths of 45' and 63'. This was underlain by a 21.5' thick layer of extremely stiff blue clay, which was in turn underlain by a wet layer of sand and gravel extending from 91' below ground level (BGL) to the terminus of the boring at 105.6'.

In the west borehole, the clay layer was underlain by various wet sand strata to a depth of 113' BGL, the terminus of the boring. The underlying sand strata were interspersed with layers of blue clay (64.5 - 66.5' BGL and 96.5 - 101' BGL) and extremely compact sand and silt (76' - 92' BGL).

The south boring initially encountered approximately 8' of sand fill resulting from removal of the former lagoon. This was underlain by the same clay stratum (26' thick) found in the other borings. The upper clay layer was underlain sequentially by compact to extremely compact wet sand (34' - 49.5' BGL), extremely stiff blue clay (49.5' - 59' BGL), wet gray sand (59' - 65.5' BGL), extremely stiff blue clay (65.5' - 87' BGL) and wet sand and gravel (87' - 100' BGL) to the end of the boring.

Temporary groundwater monitoring wells were then set in separate boreholes at the following locations:

- Northeast property corner - one screen was set at 55' BGL in the uppermost saturated zone, and one was set at 105' in the lower saturated zone;
- West property corner - one well was set at 56' BGL in the uppermost significant saturated zone;
- South of production building - one well was set at 50' BGL in the uppermost saturated zone , and one well was set at 93' BGL in the lower saturated zone.

The wells were fitted with 5' screens, and the bottom of the screens were placed at the depths listed above. After installation, the wells were developed and allowed to reach equilibrium.

Groundwater elevation measurements in each well revealed that the static water levels in all wells were the same within an absolute variance interval of $\pm 0.6'$ about the mean elevation. This indicated that all of the deeper saturated zones are hydraulically connected. The groundwater was determined to be flowing in a generally southeast direction.

Groundwater samples were collected from each temporary monitoring well and analyzed for the Priority Pollutant volatile organic species. No contaminants were found in any of the samples. This implies that there is no wide spread contamination of the usable aquifers by chlorinated solvents.

Soil samples were collected in the surficial fill materials (found to be dry or slightly moist) near each process well and analyzed for the presence of chlorinated solvents. One sample was collected approximately 8' - 10' north of the east well, and one sample was collected approximately 8' - 10' southwest of the west well. No chlorinated solvents were found in either sample, indicating that there is not a large contaminant source in the surficial soils near the process wells.

The results of this study indicate that the site is underlain by a stiff clay layer which is probably sufficient to prevent migration of solvent or metals contamination to the lower, usable saturated zones. There does not appear to be a large contaminant (solvent) plume in the deeper saturated zones.

The distance between the process wells, the low concentrations of chlorinated solvents, and the lack of solvent contamination in the surficial soils near the wells implies that the contamination discovered by the Oakland County Health Department is likely caused by migration of solvents from localized, surface spill(s) of trichloroethylene into the groundwater via the annulus surrounding the wells. This conclusion is supported by the fact that solvent transfer and storage activities have been conducted near each well.

On instructions from the Michigan Department of Health, these two wells will be abandoned, and a new water source will be established on the site. The casings of the existing wells will be destroyed in situ, and the entire borehole will be pressure sealed with grout. This action should stop any migration of contaminants via the suspected annulus route.

8.1.5 Nature and Extent of the Problem

Currently available information about the Hi-Mill site indicates that environmental contamination may have resulted from past wastewater and chemical management practices. Preliminary data have revealed the potential for contamination of site soils, surficial groundwater, surface water and sediments in an adjoining marsh, and deeper aquifers. One off-site source, Numatics, inc., has been identified as a potential contributor of contaminants identified in previous investigations.

The results of studies performed by the MDNR indicate that wastewater seeping or overflowing from the former on-site lagoons may have contaminated the surficial groundwater, lying in the upper 4' - 6' of soil, with aluminum, chromium, copper and zinc. This groundwater is flowing in a southeasterly direction toward a nearby marsh/wetland. Contaminated groundwater may be present both on-site and off-site.

Analyses of surface waters and sediments in the adjoining marsh indicate that both media may have been contaminated by wastewater discharges or contaminated surficial groundwater from the Hi-Mill property. Aluminum, copper, chromium and zinc have been found at elevated levels when compared with data from nearby lakes. A biological study of the marsh found a generally healthy ecosystem except for an absence of fish and bottom dwelling organisms. The study was inconclusive in determining if this absence was the result of variable water levels or chemical contamination. No data is currently available to allow a determination of the distribution of contaminants between the sediments and water.

There is currently no data to support an evaluation of the potential for contaminant migration beyond the marsh via the surficial groundwater or into deeper aquifers via recharge by surface water. Investigative and topographic data support the MDNR staff's conclusion that Waterbury Lake, lying southwest of the site, was not impacted by discharges at Hi-Mill as of April 1984.

The presence of elevated concentrations of metals in the surficial groundwater and in the marsh may indicate that a residual contaminant source is present on the Hi-Mill site. Some soils contaminated by wastewater management in the lagoons may still be present, but available information indicates that contaminated soils were removed at the time the lagoons were closed and excavated. Other site soils may have been contaminated by the seepage from the lagoons or the spray evaporation procedure used intermittently in 1981 - 1983 to reduce the volume of water remaining in the lagoons after their usage was terminated. The Numatics, Inc. site located approximately 1000 feet northeast of Hi-Mill is the only other potential contaminant source known at this time.

Until the recent discovery of chlorinated solvents in groundwater samples collected from Hi-Mill's two production water wells, there was no indication that deeper aquifers were potentially affected by the company's wastewater or chemical management practices. Recent analyses of well water samples showed normal and acceptable levels of water quality parameters and metals. However, the presence of trichloroethylene and cis-1,2-dichloroethylene at concentrations of 1 - 24 µg/l indicates a potential impact on the deeper, usable aquifers.

Recent subsurface stratigraphic, hydrogeological and sample analysis data indicates that the impact of these contaminants is likely to be slight and localized to the immediate vicinity of each

well. The presence of a thick (26' -45'), stiff blue clay layer lying approximately 4' - 7' under the ground surface supports the hypothesis that migration of contaminants from near-surface sources would be unlikely. The absence of chlorinated solvents in surficial soil samples collected near the wells implies that there is no large contaminant reservoir in the immediate vicinity of either well. The absence of chlorinated solvent contaminants in groundwater samples collected from the deeper aquifers implies that any contamination is localized. This conclusion is especially supported by the fact that no contaminants were observed in the samples collected from two saturated zones at a point south of the production building, downgradient from the production wells and immediately under the former lagoon.

The above data indicates that the chlorinated contaminants may likely be entering the aquifers via migration through the annuluses of the two wells. The sources of the contaminants are probably localized spills of solvent near the well heads. Trichloroethylene has been stored near both of the wells. The location and size of the contaminant source is unknown.

The scope of the RI will include examinations of potential site sources of aluminum, chromium, copper, nickel, silver, zinc and chlorinated solvents and the possible presence of these contaminants in surficial saturated zones and deeper aquifers. The RI will also collect data to evaluate the potential impact of contamination on the surface waters and sediments in the adjoining marsh. The possibility for migration of these metals from the marsh via surficial groundwater and via hydraulic connectivity with deeper aquifers will also be investigated. Atmospheric distribution of contaminants is not an issue in this program. Selected samples will also be analyzed for the TAL inorganics and TCL organics to examine the potential for contamination by other species.

8.1.6 Remedial Investigation Tasks

The Hi-Mill RI is designed to gather data to support identification of potential on-site sources of contaminants; determination of the levels and extent of contamination in surficial groundwater, deeper aquifers, and surface water and sediments in the adjoining marsh; determination of the existing and potential contaminant migration pathways between affected areas and media; and evaluation of the potential environmental and public health impact of any contamination. The results of the RI will be used to support a feasibility study into the available and most appropriate approaches for remedial action, if any is needed.

The RI strategy has been developed around the following three studies: 1) site soils, 2) on-site and off-site hydrogeology, and 3) marsh surface waters and sediments. Brief summaries of the technical approach and rationale for each of these studies are presented below. A summary of

project samples and analytes is presented in Table 8-3, and specific descriptions of samples to be collected and analytes for each are presented in Sections 2.4, 2.5, 2.6, and 2.8. A list of target analytes and their detection limits is presented in Table 8-2.

Site Soils Study

The site soils study consists of two components. The first and largest is designed to evaluate all unpaved areas of the site to identify potential sources of metals contaminants. Exposed soils on and immediately surrounding the Hi-Mill property will be divided into 60' x 60' grid squares (Section 2.4, Figure 2-2). Surface and subsurface (depths ranging from 2' to approximately 12' below grade as described in Sections 2.4.3 and 2.4.4) soil samples will be collected from each accessible grid intersection and analyzed for aluminum, copper, chromium, nickel, silver and zinc. Based on the compositions of materials (copper, brass and aluminum tubing) used in Hi-Mill's production activities and the results of previous investigations at the site (Appendix A), these are the contaminants which are reasonably expected to be present at elevated levels which could present an environmental risk. Selected samples will also be analyzed for the full lists of CLP organic and inorganic parameters to ensure that other contaminants are not present. Data from this study will provide a three dimensional profile of contaminant concentrations in the soils.

The second soils study will focus on potential trichloroethylene contamination of soils in the vicinity of the two process water wells. Soils in these two areas will be divided into 10' x 10' grid squares, and surface and subsurface samples will be collected from the center of each square. Samples will be analyzed for CLP TLC volatile organics.

Background soil samples will be collected from five different locations north and west of the study area as described in Section 2.4.6.

Hydrogeological Study

The hydrogeological study is comprised of several components designed to attain the following objectives:

- confirm the groundwater flow direction and define and characterize the contaminant plume in surficial groundwater south and east of the site;

- determine the potential for migration of contaminants in surficial groundwater beyond the southern and eastern boundaries of the marsh;
- confirm the groundwater flow direction and potential for contamination of the two deeper aquifers located at approximately 50' and 85' below ground level;
- investigate the hypothesis that trichloroethylene contamination in the process wells is localized and not part of a larger contaminant plume; and
- determine the potential for contamination of the two deeper aquifers.

The technical approach and monitoring well locations are described in detail in Sections 2.5 - 2.7.

The surficial groundwater (4' - 7' BGL) in the vicinity of the site will be investigated by utilizing existing monitoring wells and installing additional ones. Wells will be installed to create two tiers of wells east of the site between the property boundary and the marsh and to two tiers of wells near the east portion of the south boundary. Two additional wells will be installed south of the production building in the vicinity of the two former lagoons, and another will be installed northeast of the production building near the underground wastewater storage tanks. Groundwater elevation data will be used to determine flow direction, and chemical analyses (copper, chromium, aluminum, nickel, silver and zinc) of groundwater samples will be used to define the extent of contamination. Selected samples will also be analyzed for CLP TCL organic and TAL inorganic species to verify that additional contaminants are not present. Based on the compositions of materials (copper, brass and aluminum tubing) used in Hi-Mill's production activities and the results of previous investigations at the site (Appendix A), the metal analytes listed above are the contaminants which are reasonably expected to be present at elevated levels which could present an environmental risk. Samples will also be analyzed for ammonia and nitrate/nitrite to assist in determining overall groundwater quality.

Additional monitoring wells will be installed in the surficial saturated zone (4' - 8' BGL) around the south and east sides of the marsh. Groundwater samples from these wells will be analyzed for copper, chromium, aluminum, nickel, silver and zinc to determine if these contaminants have migrated south of the site or beyond the marsh. Groundwater elevation data will be used in flow direction determinations. Samples will also be analyzed for ammonia, nitrate/nitrite to assist in determining overall groundwater quality.

The potential for contamination of the uppermost usable aquifer will be determined by sampling and analysis of samples from the saturated zone lying approximately 50' below ground level. Monitoring wells will be installed in the uppermost usable aquifer in five locations to determine

groundwater flow direction and potential for contamination by copper, chromium, aluminum, nickel, silver, zinc and TCL volatile organics. TAL inorganics will be analyzed in samples from three of these wells. Wells will be installed in the northeast corner of the property (upgradient of the site), southeast (downgradient) of the west process well, south of the production building (southeast and downgradient of the east process well), south of the property boundary and north of M-59 as shown in Figure 2-3. These locations were selected to determine if contaminants from the plant property or the wetland have entered the target aquifer.

Groundwater elevation data will be used for determination of groundwater flow direction. Samples from each well will be analyzed to determine if the aquifer is contaminated. Analysis data from the two wells located downgradient from the process wells will be used to evaluate the hypothesis that the recently discovered solvent contamination is localized and not part of a larger plume. Boring log data will be used to complete the mapping of subsurface stratigraphy. Hydraulic connectivity between the 1) marsh pond and 2) surficial saturated zones and the uppermost usable aquifer will be inferred from the presence or absence of target contaminants in the latter. Slug tests will be performed to determine permeability of soils in the saturated zone.

Three monitoring wells will be installed into the saturated zone located approximately 85' - 100' below ground level. These wells will be installed southeast (downgradient) of the west process well, south of the production building (southeast and downgradient of the east process well), and south of the property boundary. Samples from these wells will be analyzed for aluminum, chromium, copper, nickel, silver, zinc and the TCL volatile organic parameters.

Surface Waters and Sediments

Samples of surface waters and sediments from the marsh will be collected from the locations described in Section 2.8 and Figures 2-5 and 2-6 and will be analyzed for copper, chromium, aluminum, silver, nickel and zinc to evaluate the levels and distribution of contaminants. Based on the compositions of materials (copper, brass and aluminum tubing) used in Hi-Mill's production activities and the results of previous investigations at the site (Appendix A), these are the contaminants which are reasonably expected to be present at elevated levels which could present an environmental risk. Four sediment and four water samples will be analyzed for the TAL inorganic parameters to ensure that other contaminants are not present in the wetland area.

Most sampling locations will be in the approximate areas where samples were previously collected by the MDNR to provide a level of data comparability. Two sample locations were selected

in the drainage area leading from the Numatics property, lying east of Hi-Mill, to the wetland to investigate the potential for contaminant contribution from the Numatics property.

Sediment samples will be collected from ten (10) stations in the wetland, two stations in Waterbury Lake and one station north of M-59 in an area which may receive water from the wetland during times of high water. Water samples will be collected from ten (10) of these stations. Background samples will be collected from a wetland, of the same classification as the marsh, located approximately 1000' southwest of Waterbury Lake. Four water and four sediment samples will be collected from evenly distributed locations in the background wetland.

8.1.7 Site Investigation Boundary Conditions

The necessity for this remedial investigation is based predominately on evidence that wastewater management practices at Hi-Mill Manufacturing have resulted in environmental contamination of surficial groundwater, surface water and sediments in the Highland State Recreational Area. The majority of investigative work in this RI will be conducted within the boundaries of the Hi-Mill property (Figure 8-3) and surrounding areas of the Highland State Recreational Area. The area of investigation in the recreation area will extend south and west to Waterbury Lake and east to the eastern boundary of the marsh/wetland. Limited activities will be conducted north of M-59 and in a wetland located approximately 1000' southeast of the site.

Collection of background samples will involve access to highway rights of way located north of the wetland, private or state property located north of Highland Road, and a wetland located in the recreational area southeast of Waterbury Lake.

This RI/FS program has been designed on the basis of currently available information to provide the data necessary to characterize the types and extents of contamination at the site and to support development of any remedial action that may be deemed necessary. However as with all such investigations, data collected during the investigation may reveal other data gaps or the need to pursue additional sampling and analysis programs to fully characterize the site. If the results of the investigation indicate that additional contaminants are present at environmentally significant levels or that contaminants from Hi-Mill activities have migrated into the uppermost usable aquifer or beyond the investigated area, the remedial investigation may be subject to modification pursuant to the consent order. If the RI scope is expanded at the conclusion of the program described herein, an amended workplan will be developed and submitted to the RPM.

8.1.8 Intended Data Usage

The data generated from the implementation of this RI is intended to be used as follows:

- Data gathered from soil sampling activities will be used to determine the nature and extent of any contaminant reservoirs that may be present on the site;
- Hydraulic conductivity, porosity data and groundwater elevations will be used to map groundwater flow direction and rate;
- Groundwater analysis data will be used to determine the nature and extent of any contaminant plume(s) found on or off site;
- Data from analysis of marsh waters and sediments will be used to determine the levels and extent of contamination.

The RI data will be used to support the endangerment assessment and feasibility study tasks. All data generated during the RI must be of sufficient quality and quantity (see Section 8.3) for future enforcement action.

8.1.9 Project Schedule

The project performance schedule is presented in Figure 8.4.

8.2 Project Organization and Responsibility

The project organization is shown schematically in Figure 8-5, and summaries of the responsibilities of key project team personnel are presented in the following subsections. Resumes of key personnel are included in Appendix D.

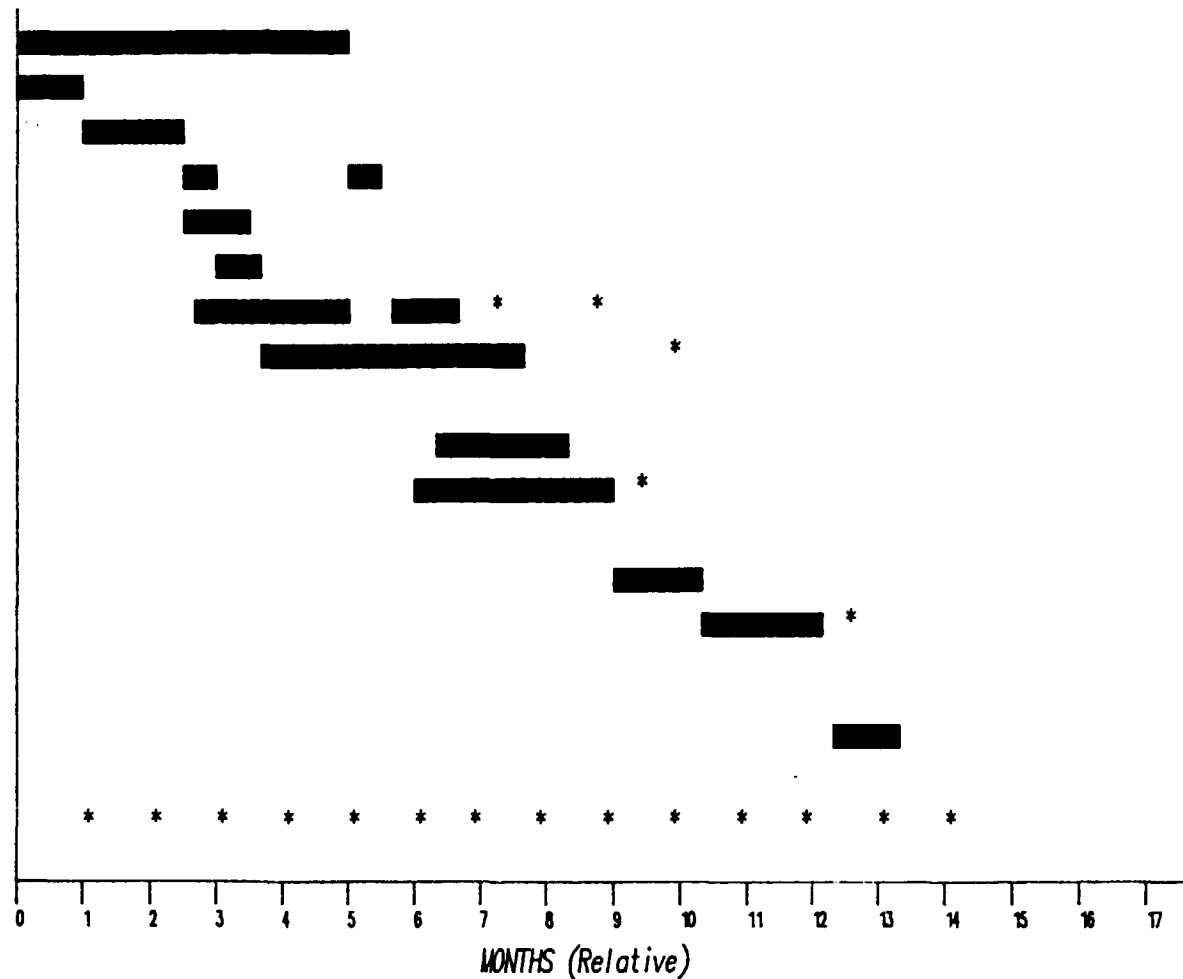
Project Manager

Dr. James Harless will serve as Project Manager Remedial Investigation Team Leader for the Hi-Mill RI/FS program. Dr. Harless will have overall technical, quality and resource management responsibilities for the project. He will ensure that the project is performed in accordance with the

FIGURE 8-4
PROJECT SCHEDULE

HI-MILL MANUFACTURING REMEDIAL INVESTIGATION

SITE MAPPING
SITE OPERATIONS PREPARATION
MONITOR WELL INSTALLATION
MONITOR WELL SAMPLING
SOIL SAMPLING
SURFACE WATER AND SEDIMENT SAMPLING
LABORATORY ANALYSES
SITE INVESTIGATION ANALYSIS
ADDITIONAL INVESTIGATION
ENDANGERMENT ASSESSMENT
DRAFT RI REPORT PREPARATION,
REVIEW AND REVISION
EPA REVIEW OF DRAFT REPORT
REVISIONS OF DRAFT REPORT AND
REVIEW AND REVISION OF FINAL
REPORT
EPA REVIEW AND APPROVAL
OF FINAL REPORT
MONTHLY PROGRESS REPORT



* - EPA DOCUMENT SUBMITTAL

**FIGURE 8-4 (Cont.)
PROJECT SCHEDULE**

HI-MILL MANUFACTURING FEASIBILITY STUDY

IDENTIFY/REVIEW REMEDIAL ACTION OPTIONS
 IDENTIFY PRT
 DEVELOP AND REVIEW PRT
 SCREEN PRT
 EVALUATE AND REVIEW ALTERNATIVES
 PREPARE/REVIEW DRAFT FEASIBILITY STUDY
 REVISE DRAFT FEASIBILITY STUDY REPORT
 EPA REVIEW OF DRAFT REPORT
 PREPARE FINAL FEASIBILITY STUDY REPORT
 EPA REVIEW OF FINAL FEASIBILITY
 STUDY REPORT
 REVISE FINAL FEASIBILITY STUDY REPORT
 PUBLIC COMMENT

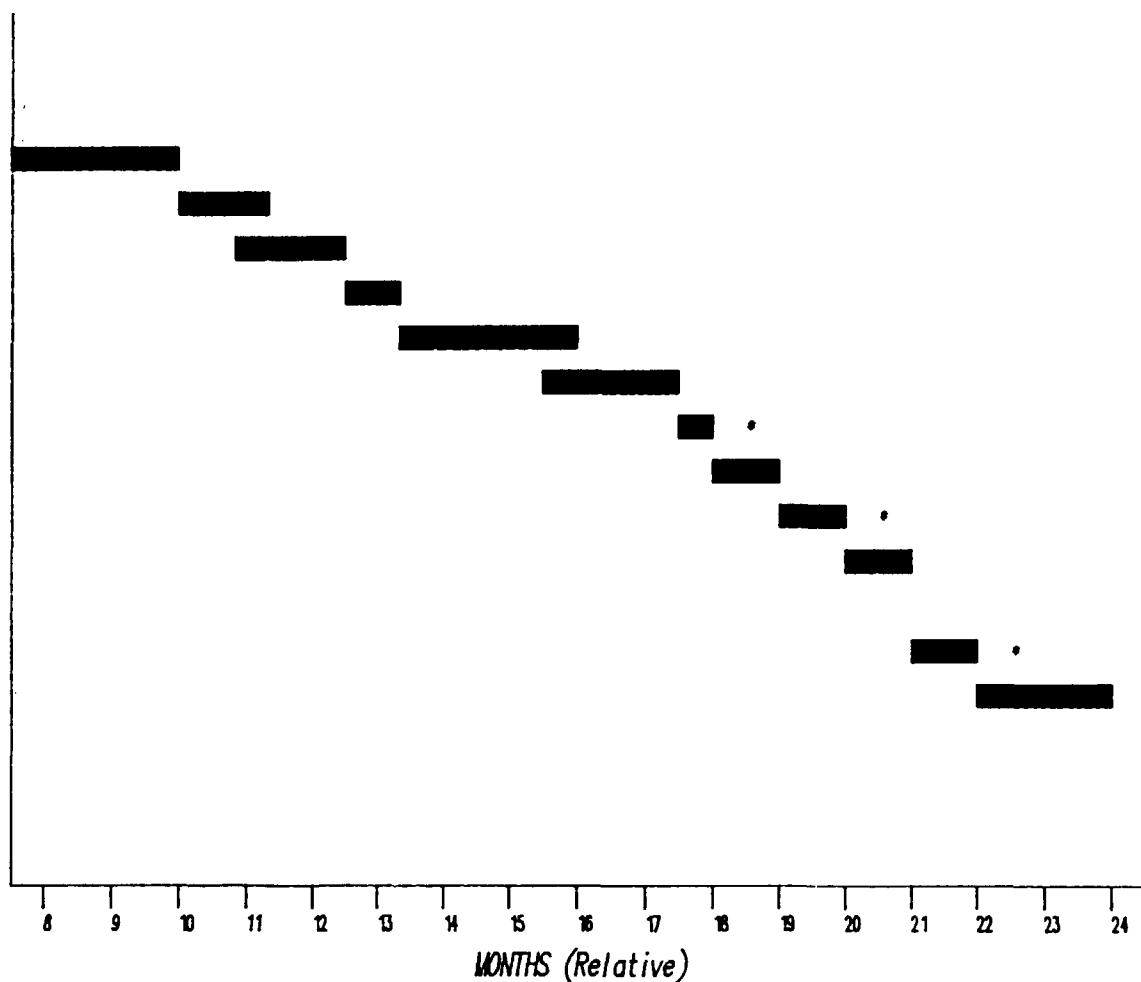
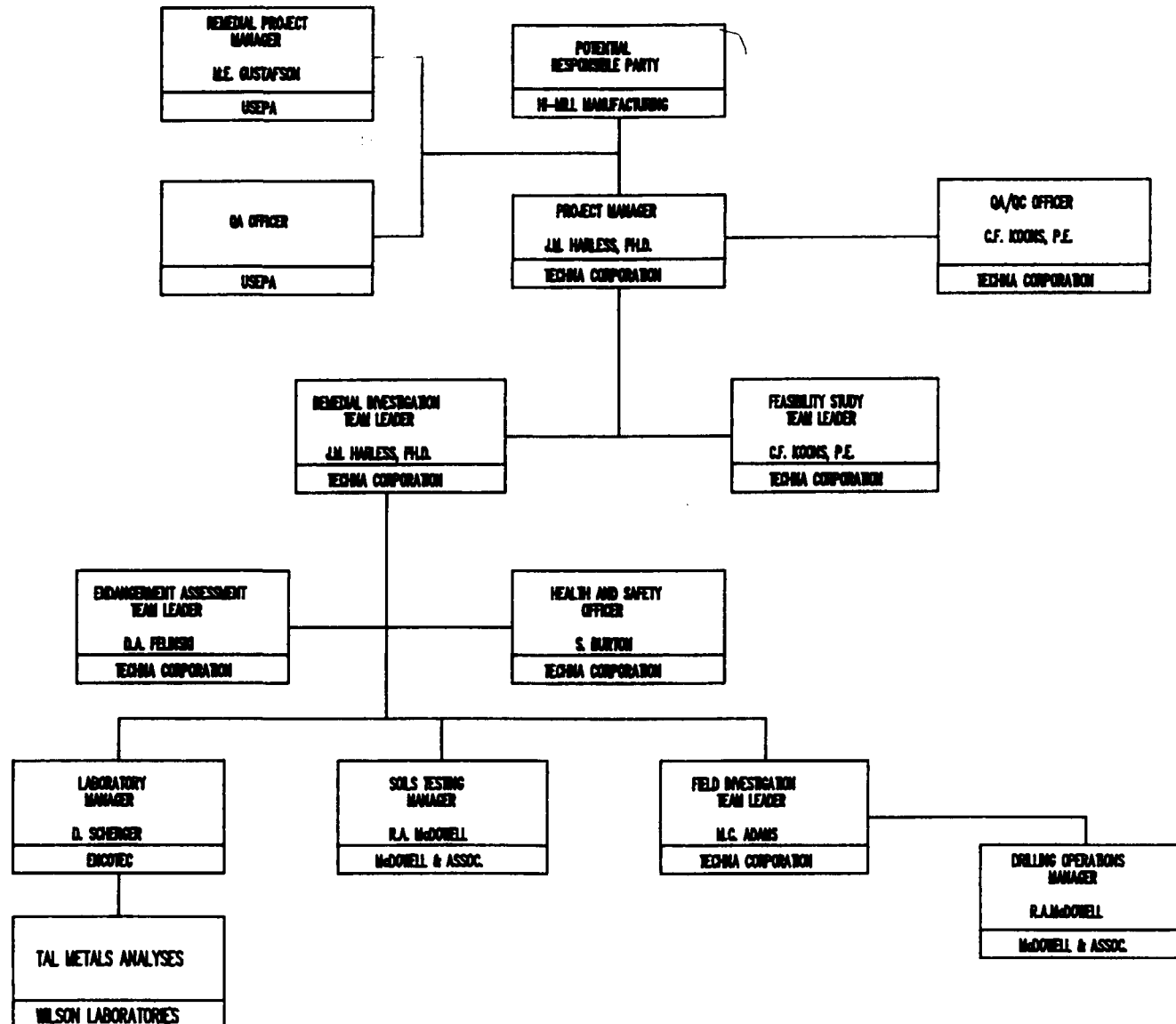


FIGURE 8-5
PROJECT ORGANIZATION DIAGRAM



work plan and performance schedule. The Project Manager will also document and approve any deviations from the approved work plan.

Field Team Leader

Ms. Mary Adams will fulfill the role of Field Team Leader for all RI site activities. Specifically, she will be responsible for all aspects of the following activities:

- surface and subsurface soils sampling,
- surface water and sediment sampling,
- groundwater monitoring well installation and sampling,
- field screening analyses, and
- site subcontractor management.

The Field Team Leader is also responsible for ensuring that the technical and schedule objectives of the RI work plan are met. She is also responsible for conducting the QA/QC related activities required of the field sampling and analysis team.

Site Safety and Health Officer

Ms. Sarah Burton will assume the responsibilities of Site Safety and Health Officer for the Hi-Mill RI site activities. These responsibilities will include verification of OSHA training certifications for site personnel, implementation of the site Health and Safety Plan, monitoring of decontamination procedures, and coordinating emergency response activities. Ms. Burton has the authority to terminate site activities in the event of safety violations or safety concerns.

Laboratory Analysis Manager

Mr. Dale Scherger, Environmental Control Technology Corporation (ENCOTEC), will serve as Laboratory Analysis Manager for all laboratory chemical analyses performed in the course of the RI. His responsibilities will include the following:

- laboratory chain-of-custody,
- analyses of TCL organic, Cr⁺⁶, ammonia and nitrate/nitrite parameters,
- QA/QC procedures and checks,

Subcontractors

Soil boring and monitoring well installation:

**McDowell and Associates, Inc.
21355 Hatcher Avenue
Ferndale, Michigan**

Aerial photography and base mapping:

**Abrams Aerial Survey, Inc.
124 N. Larch St.
Lansing, Michigan**

Consulting Hydrogeologist

**Steven J. Wright, Ph.D.
113 Engineering 1A
The University of Michigan
Ann Arbor, Michigan**

Soils testing and evaluation:

**McDowell and Associates, Inc.
21355 Hatcher Avenue
Ferndale, Michigan**

Chemical analyses

**Environmental Control Technology Corporation
3983 Research Park Drive
Ann Arbor, Michigan**

**Wilson Laboratories
P.O. Box 1820
Salina, Kansas**

External Audits

The USEPA, Region V, Central Regional Laboratory will be responsible for conducting external performance and system audits of field and laboratory activities.

8.3 Quality Assurance Objectives for Measurement Data

The quality assurance objectives described below are designed to ensure that the chemical analysis data generated during the Hi-Mill RI meet the goals of the RI, are suitable for use in the FS and are usable for any future enforcement action. Furthermore, they are intended to serve as the basis for ensuring that all data from subcontractors and field screening activities are of appropriate comparability and quality. All data quality objectives are based on guidance contained in "Data Quality Objectives for remedial Response Activities - Development Process," USEPA Publication EPA/540/G-87/003.

A summary of quality assurance objectives is presented in Table 8-1 and a list of contract method detection limits is presented in Table 8-2.

Duplicate samples are samples that have been divided into two portions at the point of field collection. Each portion is then carried through the measurement process. These duplicates will provide precision information on homogeneity, handling, shipping, storage, preparation and analysis. Duplicates will be prepared at a rate of one per ten or fewer samples for soils and waters.

Field blanks will be obtained by running analyte-free deionized water through the sample collection equipment after decontamination and then placing it in the appropriate sample container for analysis. These samples will be used to determine if the decontamination procedures are adequate. Field blanks will be collected at a rate of one per ten or fewer water samples collected.

Trip blanks will be prepared for volatile organics samples only. Organic-free, deionized water will be packaged in sample containers prior to the sampling event and will be kept with the field samples throughout the sampling and shipping activities. One trip blank will be included in each sample shipment cooler.

TABLE 8-1
ORGANIC ANALYTICAL METHOD AUDITS - WATER

<u>Parameter</u>	<u>Audit</u>	<u>Compounds</u>	<u>Control Limits</u>	
Base/neutral/ acid compounds	Lab Blank	---	± D.L.	
	Surrogate spike recovery	D5-phenol 2-fluorophenol 2,4,6-tribromophenol D5-nitrobenzene 2-fluorobiphenyl D14-terphenyl	10 to 94% 21 to 100% 10 to 123% 35 to 114% 43 to 116% 33 to 141%	
			Recovery	RPD
	Matrix spike recovery and precision	Phenol 2-chlorophenol 1,4-dichlorobenzene N-nitrosodipropylamine 1,2,4-trichlorobenzene P-chloro-n-cresol Acenaphthene 2,4-dinitrotoluene 4-nitrophenol Pentachlorophenol Pyrene	12 to 89% 27 to 123% 36 to 97% 41 to 116% 39 to 98% 23 to 97% 46 to 118% 24 to 96% 10 to 80% 9 to 103% 26 to 127%	42 40 28 38 28 42 31 38 50 50 31
Volatiles	Lab blank	---	± D.L.	
	Surrogate spike recovery	D4-1,2-dichloroethane BFB D8-toluene	76 to 114% 86 to 115% 88 to 110%	
			Recovery	RPD
	Matrix spike recovery and precision	Benzene 1,1-Dichloroethene Trichloroethene Chlorobenzene Toluene	76 to 127% 61 to 145% 71 to 120% 75 to 130% 76 to 125%	11 14 14 13 13

TABLE 8-1
(continued)

Parameter	Audit	Compounds	Control Limits	
Pesticides	Lab Blank	---	± D.L.	
	Surrogate Recovery	Dibutylchloredate	24%-154%	
			Recovery	RPD
Matrix Spike and Spike Duplicate		Lindane	56-123%	15
		Heptachlor	40-131%	20
		Aldrin	40-120%	22
		Dieldrin	52-126%	18
		Endrin	56-121%	21
		4,4'-DDT	38-127%	27

TABLE 8-1
ORGANIC ANALYTICAL METHOD AUDITS - SOIL

<u>Parameter</u>	<u>Audit</u>	<u>Compounds</u>	<u>Control Limits</u>	
Base/neutral/ acid compounds	Lab Blank	---	± D.L.	
	Surrogate spike recovery	D5-phenol	24 to 113%	
		2-fluorophenol	25 to 121%	
		2,4,6-tribromophenol	19 to 122%	
		D5-nitrobenzene	23 to 120%	
		2-fluorobiphenyl	30 to 115%	
		D14-terphenyl	18 to 137%	
	Matrix spike recovery and precision		Recovery	RPD
		Phenol	26 to 90%	35
		2-chlorophenol	25 to 102%	50
		1,4-dichlorobenzene	28 to 104%	27
		N-nitrosodipropylamine	41 to 126%	38
		1,2,4-trichlorobenzene	38 to 107%	23
		P-chloro-n-cresol	26 to 103%	33
		Acenaphthene	31 to 137%	19
		2,4-dinitrotoluene	28 to 89%	47
		4-nitrophenol	11 to 114%	50
Volatiles	Lab Blank	---	± D.L.	
	Surrogate spike recovery	D41,2-dichloroethane	70 to 121%	
		BFB	74 to 121%	
		D8-toluene	81 to 117%	
	Matrix spike recovery and precision		Recovery	RPD
		Benzene	66 to 142%	21
		1,1-Dichloroethene	59 to 172%	22
		Trichloroethene	62 to 137%	24
		Chlorobenzene	60 to 133%	21
		Toluene	59 to 139%	21

TABLE 8-1
(continued)

Parameter	Audit	Compounds	Control Limits	
Pesticide/PCB	Lab Blank	---	± D.L.	
	Surrogate Recovery	Dibutylchloredate	20-150%	
			Recovery	RPD
Matrix Spike and Spike Duplicate		Lindane	46-127%	50
		Heptachlor	35-130%	31
		Aldrin	34-132%	43
		Dieldrin	31-134%	38
		Endrin	42-139%	45
		4,4'-DDT	23-134%	50

Table 8-1
INORGANICS METHOD AUDITS

<u>Parameter</u>	<u>Audit</u>	<u>Control Limits</u>
<u>Flame AA/ICP</u>		
Al, Cr, Ba, Be, Co, Cu, Fe, Ni, Mn, Zn, V, Ag, Sb, Cd, Pb, Ca, Mg, K, Na, Tl	Lab Blank Calibration Verification Continuing calibration Preparation blank Matrix spike Sample duplicate Lab control sample Detection limit check	≤ D.L. 90 to 110% 90 to 110% ± D.L. 75-125% ± D.L. or 20% RPD 80-120% ≤ D.L.
<u>Furnace AA</u>		
Al, Cr, Ba, Be, Co, Cu, Ni, Mn, V, Ag, As, Sb, Se, Tl, Cd, Pb	Lab blank Calibration verification Continuing calibration Preparation blank Matrix spike Sample duplicate Lab control sample Detection limit check Duplicate injections	≤ D.L. 90 to 110% 90 to 110% ± D.L. (Every sample, see QC decision tree) ± D.L. or 20% RPD 80 to 120% ≤ D.L. ± 20% RPD
<u>Cold Vapor</u>		
Mercury	Lab blank Calibration verification Continuing calibration Preparation blank Matrix spike Sample duplicate Lab control sample Detection limit check	≤ D.L. 80 to 120% 80 to 120% ± D.L. 75 to 125% ± D.L. or 20% RPD 80 to 120% ≤ D.L.
<u>Distillation, Spectrophotometric</u>		
Cyanide	Lab blank Calibration verification (Distilled) Continuing calibration Preparation blank (Distilled) Distilled spike Distilled duplicate Lab control sample Detection limit check	≤ D.L. 85-115% 85-115% ± D.L. 75-125% ± D.L. or 20% RPD 80-120% ≤ D.L.

TABLE 8-2

TCL VOLATILE ORGANICS

<u>Compound</u>	<u>CAS #</u>	<u>PP #</u>	<u>Reporting Limits</u>	
			<u>Soil/ Sediment ug/kg</u>	<u>Wells & Surface Water ug/l</u>
Acetone	67-64-1	2V	10	10
Benzene	71-43-2	4V	5	5
2-Butanone	78-93-3		10	10
Bromodichloromethane	75-27-4	48V	5	5
Bromoform	75-25-2	47V	5	5
Bromomethane	74-83-9	46V	10	10
Carbon Disulfide	75-15-0		5	5
Carbon Tetrachloride	56-23-5	6V	5	5
Chlorobenzene	108-90-7	7V	5	5
Chloroethane	75-00-3	16V	10	10
Chloroform	67-66-3	23V	5	5
Chloromethane	74-87-3	45V	10	10
Chlorodibromomethane	124-48-1	51V	5	5
1,1-Dichloroethane	75-34-3	13V	5	5
1,2-Dichloroethane	107-06-2	10V	5	5
1,1-Dichloroethene	75-35-4	29V	5	5
trans-1,2-Dichloroethene	540-59-0	30V	5	5
trans-1,2-Dichloropropene	78-87-5	32V	5	5
cis-1,3-Dichloropropene	10061-01-5		5	5
trans-1,3-Dichloropropene	10061-02-6	33V	5	5
Ethylbenzene	100-41-4	38V	5	5
2-Hexanone	591-78-6		10	10
Methylene Chloride	75-09-2	44V	5	5
4-Methyl-2-Pentanone	108-10-1		10	10
Styrene	100-42-5		5	5
1,1,2,2-Tetrachloroethane	79-34-5	15V	5	5
Tetrachloroethene	127-18-4	85V	5	5
Toluene	108-88-3	86V	5	5
1,1,1-Trichloroethane	71-55-6	11V	5	5
1,1,2-Trichloroethane	79-00-5	14V	5	5
Trichloroethene	79-01-6	87V	5	5
Vinyl Acetate	108-05-4		10	10
Vinyl Chloride	79-01-4	88V	10	10
Total Xylenes	1330-20-7		5	5

(a) Compounds without PP No. are TCL compounds not on Priority Pollutant List
 (b) USEPA CLP SOW 2/88, Methods

TABLE 8-2

TCL SEMIVOLATILE ORGANICS

<u>Compound</u>	<u>CAS #</u>	<u>PP #</u>	<u>Reporting Limits</u>	
			<u>Soil/ Sediment ug/kg</u>	<u>Wells & Surface Water ug/l</u>
Acenaphthene	83-32-9	1B	330	10
Acenaphthylene	208-96-8	77B	330	10
Anthracene	120-12-7	78B	330	10
Benzo(a)anthracene	56-55-3	72B	330	10
Benzo(b)fluoranthene	205-99-2	74B	330	10
Benzo(k)fluoranthene	207-08-9	75B	330	10
Benzo(ghi)perylene	191-24-2	79B	330	10
Benzoic Acid	65-85-0		1,600	50
Benzo(a)pyrene	50-32-8	73B	330	10
Benzyl Alcohol	100-51-6		330	10
Bis(2-chloroethoxy)methane	111-91-1	43B	330	10
Bis(2-chloroethyl) Ether	111-44-4	18B	330	10
Bis(2-chloroisopropyl) Ether	108-60-1	42B	330	10
Bis(2-ethylhexyl) Phthalate	117-81-7	66B	330	10
4-Bromophenyl Phenyl Ether	101-55-3	41B	330	10
Butyl Benzyl Phthalate	85-68-7	67B	330	10
4-Chloroaniline	106-47-8		330	10
4-Chloronaphthalene	91-58-7	20B	330	10
4-Chlorophenyl Phenyl Ether	7005-72-3	40B	330	10
Chrysene	218-01-9	76B	330	10
Dibenzo(a,h)anthracene	53-70-3	82B	330	10
Dibenzofuran	132-64-9		330	50
Di-n-butyl Phthalate	84-74-2	68B	330	10
1,2-Dichlorobenzene	95-50-1	25B	330	10
1,3-Dichlorobenzene	541-73-1	26B	330	10
1,4-Dichlorobenzene	106-46-7	27B	330	10
3,3'-Dichlorobenzidine	91-94-1	28B	660	20
Diethyl Phthalate	84-66-2	70B	330	10
Dimethyl Phthalate	131-11-3	71B	330	10
2,4-Dinitrotoluene	121-14-2	35B	330	10
2,6-Dinitrotoluene	606-20-2	36B	330	10
Di-n-octyl Phthalate	117-84-0	69B	330	10
Fluoranthene	206-44-0	39B	330	10
Fluorene	86-73-7	80B	330	10
Hexachlorobenzene	118-74-1	9B	330	10
Hexachlorobutadiene	87-68-3	52B	330	10
Hexachlorocyclopentadiene	77-47-4	53B	330	10
Hexachloroethane	67-72-1	12B	330	10

Table 8-2

TCL SEMIVOLATILE ORGANICS
(continued)

<u>Compound</u>	<u>CAS #</u>	<u>PP #</u>	<u>Reporting Limits</u>	
			<u>Soil/ Sediment ug/kg</u>	<u>Wells & Surface Water ug/l</u>
Indeno(1,2,3-cd)pyrene	193-39-5	83B	330	10
Isophorone	78-59-1	54B	330	10
2-Methylnaphthalene	91-57-6		330	10
Naphthalene	91-20-3	55B	330	10
2-Nitroaniline	88-74-4		1,600	50
3-Nitroaniline	99-09-2		1,600	50
4-Nitroaniline	100-01-6		1,600	50
Nitrobenzene	98-95-3	56B	330	10
N-Nitrosodiphenylamine*	86-30-6	62B	330	10
N-Nitroso-dipropylamine	621-64-7	63B	330	10
Phenanthrene	85-01-8	81B	330	10
Pyrene	129-00-0	84B	330	10
1,2,4-Trichlorobenzene	120-82-1	8B	330	10
P-chloro-r-cresol	59-50-7	22A	330	10
2-Chlorophenol	95-57-8	24A	330	10
4-Dichlorophenol	120-83-2	31A	330	10
2,4-Dimethylphenol	105-67-9	34A	330	10
4,6-Dinitro-2-methylphenol	534-52-1	60A	1,600	50
2,4-Dinitrophenol	51-28-5	59A	1,600	50
2-Methylphenol	95-48-7		330	10
4-Methylphenol	108-39-4		330	10
2-Nitrophenol	88-75-5	57A	330	10
4-Nitrophenol	100-02-7	58A	1,600	50
pentachlorophenol	87-86-5	64A	1,600	50
Phenol	108-95-2	65A	330	10
2,4,5-Trichlorophenol	95-95-4		1,600	50
2,4,6-Trichlorophenol	88-06-2	21A	330	10

- a) Compounds without PP No. are TCL compounds not on Priority Pollutant List
b) USEPA CLP SOW 2/88, Methods

Table 8-2

TCL PESTICIDES AND PCB

<u>PESTICIDE/PCB</u>	<u>CAS #</u>	<u>Reporting Limits</u>	
		<u>Soil/ Sediment ug/kg</u>	<u>Well & Surface Water ug/l</u>
Aldrin	309-00-2	8.0	0.05
Alpha-BHC	319-84-6	8.0	0.05
Beta-BHC	319-85-7	8.0	0.05
Gamma-BHC	58-89-9	8.0	0.05
Delta-BHC	319-86-8	8.0	0.05
Chlordane	57-74-9	80	0.5
4,4'-DDD	72-54-8	16.0	0.10
4,4'-DDE	72-55-9	16.0	0.10
4,4'-DDT	50-29-3	16.0	0.10
Dieldrin	60-57-1	16.0	0.10
Alpha-Endosulfan	959-98-8	8.0	0.05
Beta-Endosulfan	33213-65-9	16.0	0.10
Endrin	72-20-8	16.0	0.10
Endrin Ketone	53494-70-5	16.0	0.10
Endosulfan Sulfate	1031-07-8	16.0	0.10
Heptachlor	76-44-8	8.0	0.05
Heptachlor Epoxide	1024-57-3	8.0	0.05
Methoxychlor	72-43-5	80	0.5
PCB-1016	12674-11-2	80	0.5
PCB-1221	11104-28-2	80	0.5
PCB-1232	11141-16-5	80	0.5
PCB-1242	53469-21-9	80	0.5
PCB-1248	12572-29-6	80	0.5
PCB-1254	11097-69-1	160	1.0
PCB-1260	11096-82-5	160	1.0
Toxaphene	80001-35-2	160	1.0

USEPA CLP SOW, 2/88, Methods

Table 8-2
(continued)

Inorganic Target Analyte List (TAL)

<u>Parameter</u>	<u>Method</u>	<u>Reporting Limits</u>	
		<u>Soil/ Sediment mg/kg</u>	<u>Well & Surface Water ug/l</u>
Aluminum	200.1	40	200
Antimony	204.2	12	60
Arsenic	206.2	2	10
Barium	200.1	40	200
Beryllium	200.1	1	5
Cadmium	200.1	1	5
Calcium	200.1	1000	5000
Chromium	200.1	2	10
Cobalt	200.1	10	50
Copper	200.1	5	25
Iron	200.1	20	100
Lead	239.2	0.6	3
Magnesium	200.1	1000	5000
Manganese	200.1	3	15
Mercury	245.1/245.5	0.1	0.2
Nickel	200.1	8	40
Potassium	200.1	1000	5000
Selenium	270.2	1	5
Silver	200.1	2	10
Sodium	200.1	1000	5000
Thallium	279.2	2	10
Vanadium	200.1	10	50
Zinc	200.1	4	20
Cyanide	335.2	0.5	10
Hexavalent Chromium*	7196	0.5	10
Ammonia	350.1		50
Nitrate/Nitrite	353.2		50

Note: Due to unforeseeable circumstances some samples may be analyzed by a different method as long as the limits are met. Example = ICP becomes non-functional, therefore use Flame AA.

Reference: *USEPA Methods, SW-846, Third Edition for Hexavalent Chromium
USEPA CLP SOW 7/88, Methods for other metals.

One set of bottle blanks will be run for each analyte. The results of these blanks should be less than MDL for all analytes except acetone and methylene chloride.

8.3.1 Precision

Precision is the measure of agreement among measurements performed using the same test procedure. Precision (RPD) is measured by dividing the difference in results of analyses of two replicate spike samples by the mean of the two results, then multiplying by 100. The precision requirements for this RI are defined in the USEPA Contract Laboratory Program SOW 288 for organic parameters and the SOW 788 for inorganic parameters. The precision requirements for field measurements will be as follows: pH - 0.05 S.U.; specific conductivity - 2% of scale; temperature - 0.5°C.

8.3.2 Accuracy

Accuracy is the level of agreement between the measured value of an analyte and the true, or known, value of that parameter. For this project, accuracy will be measured by calculating the percent recovery (R) of known levels of spike compounds in appropriate sample matrices. The specific methodologies and precision requirements for this RI are defined in the USEPA Contract Laboratory Program SOW 288 for organic parameters and the SOW 788 for inorganic parameters. The accuracy requirements for field measurements will be as follows: pH - 0.07 S.U.; specific conductivity - 4% of scale; temperature - 1.5°C.

8.3.3 Data Representativeness

The data collection activities, described more fully in Section 2.0, for the Hi-Mill RI program have been designed to provide representative data. Sampling locations have been chosen so that the results of chemical analyses of the collected samples will provide sufficient data determine the following:

- the extent of site soils contamination,
- the extent of surficial groundwater contamination;
- the extent of surface water and sediment contamination; and
- the potential for contamination of and/or contaminant migration to the uppermost usable aquifer.

Initial soils sampling activities are designed to fully characterize the potential trace metal contaminants in the surface soils at the site through unbiased grid sampling. Volatile organic contaminants will be characterized through unbiased grid sampling in areas of higher contamination probability and through directed sampling in other areas of the site.

Surface water and sediment sampling activities in the target wetland are designed to characterize potential trace metals contaminants through a directed sample collection program. Samples will be collected in locations which will allow full characterization of the wetland and also be consistent and comparable to samples collected in previous studies.

Shallow groundwater monitoring wells are located to allow determination of the groundwater flow direction and potential for contamination of the surficial saturated zone. Deeper monitoring wells are located to assess the potential for contamination in the uppermost usable aquifer and to determine if the surficial saturated zone and surface waters are hydraulically connected.

Background soil samples will be collected from two locations near the Hi-Mill site to determine the potential impact of contaminants in highway run-off. The results will be evaluated to determine the most representative background data. Representative background surface water and sediment samples will be collected from Waterbury Lake and a nearby wetland having the same wetland classification as the one in the study area.

8.3.4 Data Comparability

All data will be reported in units which ensure comparability and usability of data within sample matrix groups and within data use groups. Laboratory data for aqueous samples will be reported in ug/l (ppb) or mg/l (ppm). Data for soil samples will be reported in ug/kg (ppb) or mg/kg (ppm).

8.3.5 Data Completeness

Data completeness for this project will be determined as the number of obtained valid data points divided by the number of analyses performed. The completeness objective for this project is 95% for all samples except background samples, which will have a 100% objective.

8.4 Sampling Procedures

The procedures and methodologies that will be used for the collection of samples during Hi-Mill RI activities are described in detail in Section 2.0 of this document. Specific sampling techniques that will be used for each sample matrix are referenced as follows:

- Soils - Sections 2.4 and 2.5.3,
- Groundwater - Section 2.6,
- Surface waters and sediments - Section 2.9.

A summary of the samples that will be collected and the related chemical analysis parameters is presented in Table 8-3. Descriptions of the sample bottles that will be used and the holding times that will be observed for each sample type are presented in Table 8-4.

8.5 Chemical Analysis Procedures

Chemical analyses of samples collected during this RI will be performed both in the field and in the laboratories of ENCOTEC and Wilson Laboratories. Field analysis procedures will include pH and temperature measurements of surface and groundwater samples at time of collection and specific conductivity measurements of groundwater samples. Analysis procedures that will be employed for these samples are presented in Section 2.6.

Soil, surface water, sediment and groundwater samples collected for analyses of Target Compound List (TCL) metals and organic parameters will be transported to ENCOTEC laboratories in Ann Arbor, Michigan for preparation and analysis. A summary of sample matrices, preservation techniques, holding times, and containers is presented in Table 8-4. More detailed descriptions of analysis methodologies are presented below.

TCL Organic Parameters

Soil and groundwater samples collected for analysis of TCL volatiles, extractables, pesticides and PCBs will be analyzed using the procedures defined in the Contract Laboratory Organics SOW 288. All sample preparation, analysis, QA/QC protocols specified in this SOW will be followed.

TCL Volatile Organics

Soil and groundwater samples collected for analysis of TCL volatile organic species will be analyzed using the procedures defined in the Contract Laboratory Organics SOW 288. All sample preparation, analysis, QA/QC protocols specified in this SOW will be followed.

The analysis procedures will be modified only insofar as the sample preparation and analysis procedures for extractable and pesticide/PCB species will not be performed. The sample preparation, analysis, QA/QC, and reporting procedures directly associated with the volatile fraction will be implemented as specified in the reference SOW.

TCL Trace Metals - Aluminum, Copper, Chromium, Nickel, Silver and Zinc

Soil, sediment and water samples collected for analysis of the TCL trace metals aluminum, chromium, copper, nickel, silver and zinc will be analyzed using the procedures defined in the Contract Laboratory Inorganics SOW 788. All sample preparation, analysis, QA/QC protocols specified in this SOW will be followed.

The SOW procedures will be modified in that only the four metals specified above will be analyzed. Sample spiking, instrument calibration, sample preparation, analysis, reporting, and other QA/QC procedures for the remaining TCL metals will not be performed.

Hexavalent Chromium, Ammonia, Nitrate/Nitrite

Surface water and sediment samples will be analyzed for hexavalent chromium according to USEPA Method 7196, SW-846, Third Edition. Selected groundwater and surface water samples (Section 2) will be analyzed for ammonia and nitrate/nitrite according to USEPA methods 350.1 and 353.2 respectively. Copies of the analysis SOP's are attached in Appendix B.

Required contract detection limits for all chemical analysis parameters are summarized in Table 8-2.

TABLE 8-3
SUMMARY OF SAMPLING PROGRAM

<u>Sample Type/Matrix</u>	<u>Field Measurements</u>	<u>Laboratory Parameters</u>	<u>Number of Samples</u>	<u>Field Duplicates</u>	<u>Field Blanks</u>	<u>Matrix Total</u>	<u>Trip Blanks</u>
Surface/Subsurface Soils		TAL Al, Cr Cu, Ni, Ag & Zn	179	18		197	
		TAL Inorganics	28	3		31	
		TCL Volatiles	76	8		84	
		TCL B/N/A	13	2		15	
		TCL Pest./PCB	13	2		15	
		Grain size	9	1		10	
		Atterberg limits	9	1		10	
		Hydraulic Cond.	14	2		16	
		Moisture content	9	1		10	
Groundwater (Phase I)		TAL Al, Cr Cu, Ni, Ag & Zn	23	3	3	29	
		TAL Inorganics	6	1	1	8	
		TCL Volatiles	19	2	2	23	1/shipment cooler
		TCL B/N/A	3	1	1	5	
		TCL Pest./PCB	3	1	1	5	
		NH ₃ , NO ₃ /NO ₂	21	3	3	27	
	pH, Temp., Sp.Cond.		29	3		32	

TABLE 8-3 (Cont.)
SUMMARY OF SAMPLING PROGRAM

Sample Type/Matrix	Field Measurements	Laboratory Parameters	Number of Samples	Field Duplicates	Field Blanks	Matrix Total	Trip Blanks
Groundwater (Phase II)		TAL Al, Cr Cu, Ni, Ag & Zn	23	3	3	29	
		TAL Inorganics	6	1	1	8	
		TCL Volatiles	19	2	2	23	1/shipment cooler
		TCL B/N/A	3	1	1	5	
		TCL Pest./PCB	3	1	1	5	
		NH ₃ , NO ₃ /NO ₂	21	3	3	27	
	pH, Temp., Sp.Cond.		29	3		32	
Surface Water		TAL Al, Cr Cu, Ni, Ag & Zn	10	1	1	12	
		TAL Inorganics	4	1	1	6	
		Cr+6	14	2	2	18	
		NH ₃ , NO ₃ /NO ₂	3	1	1	5	
Sediment		TAL Al, Cr Cu, Ni, Ag & Zn	18	2		20	
		TAL Inorganics	4	1		5	
		Cr+6	22	3		25	

Table 8-4
Sample Containers and Preservatives

<u>Parameter</u>	<u>Container</u>	<u>Preservation</u>	<u>Holding Time</u>
<u>Soil/Sediments Samples</u>			
Volatile Organics	Glass Vials (2-120 ml)	Cool 4°C	10 Days
Metals	Wide Mouth Glass (1-8 oz; 3/4 full)	Cool 4°C	180 Days Except Mercury 26 Days
Hexavalent Chromium	Wide Mouth Glass (1-4 oz; 3/4 full)	Cool 4°C	24 hours for Extract Analysis
Semivolatiles and Pesticide/PCB	Wide Mouth Glass (1-8 oz; 3/4 full)	Cool 4°C	10 Days Extraction 40 Days Analysis
Cyanide	Wide Mouth Glass (1-8 oz; 3/4 full)	Cool 4°C	12 Days
<u>Well Water/Surface Water Samples</u>			
<u>Parameter</u>	<u>Container</u>	<u>Preservation</u>	<u>Holding Time</u>
Volatile Organics	Glass Vial with Teflon Septum (2-40 ml) Full-No Headspace	1:1 HCL, pH<2 Cool 4°C	10 Days
Metals (A)	Polyethylene (1-1 Liter)	HNO ₃ , pH<2	180 Days Except Mercury - 26 Days
Hexavalent Chromium	Polyethylene (1-0.5 Liter)	Cool 4°C	24 hours
Semivolatiles (BNA)	Amber Glass (1-2 Liter)	Cool 4°C	5 Days Extraction 40 Days Analysis
Pesticide/PCB	Amber Glass (1-2 Liter)	Cool 4°C	5 Days Extraction 40 Days Analysis
Cyanide	Polyethylene (1-1 Liter)	0.6 gr Ascorbic Acid NaOH, pH>12 Cool 4°C	12 Days

(A) A 0.45 Micron filter will be used to field filter each water sample for analysis

Note: Holding times are from date of receipt by Laboratory

8.6 Sample Custody

Chain of custody procedures have been developed for compliance with "NEIC Policies and Procedures" (EPA-330/9-78-001-R, revised May 1988). These procedures include sample custody during both field and laboratory activities and custody and management of the Final Evidence File.

A sample or evidence file is defined as being in custody if any one of the following situations is applicable:

- it is in a person's possession;
- it is in view of a person after having been in that person's possession,
- it was in a person's possession and was then placed in a secure location, or
- it is in a designated secure location.

8.6.1 Field Custody Procedures

The Field Team will be responsible for maintaining custody of all samples from the time they are collected until they are relinquished to the chemical analysis laboratory or to a transporter for shipment to the laboratory. Field custody activities and procedures are divided into the following two areas: 1) sample collection and documentation and 2) custody transfer.

The viability of all samples collected during the RI depend on proper collection and containerization procedures (Section 2.0), proper documentation, and proper custody transfer procedures. The following field operations procedures will be used to ensure that all samples are properly documented and that custody is maintained:

- 1) The field sampler is personally responsible for the documentation, care and custody of the samples until they are transferred or properly dispatched. As few people as possible should handle the samples.
- 2) The field sampler is responsible for recording all daily activities in a serially page-numbered field logbook. The following information will be recorded for each sample collected:

- a) Sample identification number;
- b) Accurate and complete description of sample location and depth below ground level;
- c) Date and time of sample collection;
- d) Physical description of the sample;
- e) Description of sample container and preservatives;
- f) Notations for any deviations from planned procedures for sampling, decontamination, etc. procedures;
- g) Results of field screening/analysis procedures;
- h) Reference numbers for any documents on which the sample is listed, such as airbills, labels, chain-of-custody forms, etc.;
- i) Names of sample collectors(s) and signature of person making entries.

In addition, any other data that may have a bearing on the nature of the sample or that may be significant to the interpretation of the results shall be noted in the field log. Weather conditions will also be recorded in the field log at least three times per day.

- 3) All sample containers will be tagged with the appropriate sample number, location and description. Sample labels/tags shall be prepared using waterproof ink unless prevented by weather conditions. If a marker other than that described above is used, a field log entry shall be made to explain the deviation. The following information will be recorded on each tag:

- a) Project name/number;
- b) Sample identification number;
- c) Sample location/description;
- d) Name of sampling personnel;
- e) Date and time of collection;
- f) Type(s) of preservatives;
- g) Analyses requested;
- h) Special handling information.

- 4) The Field Team Leader shall review all field activities to determine whether proper custody procedures were followed during the work and decide if additional samples are required.


Sampling team personnel will retain custody of all samples until shipment to the chemical analysis laboratory.

When the custody of samples is transferred, the custody record will be maintained through use of a chain-of-custody (COC) form (Figure 8-6). One COC custody form will be used for each sample shipping container. The following procedures will be used for transfer of custody and transport of samples to the analysis laboratory:

- 1) Samples will be accompanied by a properly completed chain-of-custody form. A typical COC form is presented in Figure 8-6. When transferring the possession of samples, the individuals relinquishing and receiving custody will sign, date and note the time on the record. This record documents the transfer of custody of samples from the sampler to another person, the transporter, the laboratory or to and from secure storage.
- 2) Samples will be properly packaged for shipment and dispatched to the appropriate laboratory for analysis, with the completed and signed custody form enclosed in each sample box or cooler. Shipping containers will be secured with strapping tape and custody seals prior to shipment to the laboratory.
- 3) Whenever samples are split with a government agency, a notation will be entered by the Field Team Leader in a field log to indicate the sample number and with whom the sample was split. A separate Receipt for Sample form will be prepared, and the representative of the agency receiving the split samples will be asked to sign the form to acknowledge receipt of samples. If a representative is unavailable or refuses to sign, this will be noted in the signature space.
- 4) All shipments will be accompanied by the chain-of-custody record identifying the contents. The original record will accompany the shipment, and a copy will be retained by the Project Manager.

FIGURE 8-6

CHAIN OF CUSTODY RECORD

Proj. No		Project Name				No. of Con- tainers											Remarks
Samplers: (Signature)																	
Sta. No.	Date	Time	Comp	Grab	Station Location												
Relinquished by: (Signature)			Date/Time		Received by: (Signature)		Relinquished by: (Signature)			Date/Time		Received by: (Signature)					
Relinquished by: (Signature)			Date/Time		Received by: (Signature)		Relinquished by: (Signature)			Date/Time		Received by: (Signature)					
Relinquished by: (Signature)			Date/Time		Received for Laboratory by: (Signature)				Remarks:								
			Knowledge, and the Creativity to Use It				44808 Helm Street Plymouth, Michigan 48170 (313) 454-1100										

- 5) If the samples are sent by common carrier, receipts of a bill of lading will be retained as part of the permanent documentation. If samples are sent by mail, the package will be registered with return receipt requested.

8.6.2 Laboratory Custody Procedures

Samples will be received at the laboratory by the sample custodian who will verify that the information on the sample tags matches that on the COC form. The sample custodian will then assign a unique laboratory number to each sample and transfer them to the appropriate secure storage area.

The sample custodian will distribute samples to the appropriate analysts and will ensure that proper laboratory custody records are maintained. Laboratory personnel are responsible for the samples until they are exhausted or returned to the secure storage area.

When sample analyses and necessary quality assurance checks have been completed, the unused portion of the sample will be properly disposed. All identifying tags, data sheets and laboratory records will be retained as part of the permanent record file. Original magnetic data tapes will be stored in locked cabinets, and disk copies will be used for data processing.

Additional details concerning ENCOTEC's laboratory custody procedures are included in Appendix B.

8.6.3 Final Evidence File

The final evidence file for the Hi-Mill RI/FS project will consist of the laboratory data and QA/QC packages (summary and raw data, chromatograms, mass spectra, calibration data, worksheets, COC forms, etc.) and RI field data and documents (field logs, photographs, reports and subcontractor reports). The final evidence file will be stored in a secure, limited access area at Techna's corporate headquarters.

8.7 Calibration Procedures and Frequencies

A maintenance, calibration and operation program will be implemented to ensure that routine calibration and maintenance is performed on all field and laboratory instruments.

8.7.1 Field Instruments

The field instrument calibration program will be implemented by the QA/QC Officer and the members of the field team. Team members are familiar with the field calibration, operation and maintenance of the equipment, and they will perform these functions prior to use of the equipment and periodically during use as prescribed in the operating procedures. Maintenance, calibration and operation of equipment will follow the procedures outlined in the USEPA's "Technical Methods for Investigations of Sites Containing Hazardous Substances."

pH Meter

The pH meter that will be used is a Presto-Tek Corporation Model DspH-3. Calibration of the pH meter will be performed at the start of each day of use and after every four hours of use thereafter. Standard buffer solutions traceable to the National Bureau of Standards will be used. Since all aqueous samples tested will be surface or ground waters, calibration standards having pH values of 4.0 and 7.0 standard units will be used. If samples with higher pH are encountered, a buffer standard of 10.0 will be used as appropriate to increase the accuracy. The instrument calibration and slope controls will be used according to operating instructions to adjust the meter display to match the standards being used.

If instrument problems, such as slow response, inability to maintain calibration, instability, etc. are encountered, the instrument will be removed from service and replaced. Appropriate internal calibrations, maintenance and/or repairs will be performed as necessary to return the instrument to proper operating condition.

Specific Conductivity Meter

A Presto-Tek Model DspH-3 specific conductivity meter will be used during this project. Calibration checks using commercial conductivity standards will be performed at the start of each day of use. Concentration ranges of the standard aqueous solutions of potassium chloride will be selected to allow calibration bracketing of the range of conductivity values experienced in the field samples.

Temperature Meter

An Omega Model HH-51 digital thermometer will be used for all temperature measurements. The digital thermometer will be calibrated at the beginning of each day of use and at any other time that field team members become concerned about measurement accuracy. The thermometer will be calibrated at the ice point (0° C) using an Omega Model MCJ electronic ice point calibrator. The calibration data will be recorded in field logs and on calibration log sheets maintained on-site.

Ambient Air Gas Detection Instrument

A Gastech Model GX-82 HS will be used to for the detection and measurement of flammable gases, oxygen levels and hydrogen sulfide to ensure the safety of the sampling team during advancement of soil borings. The data from this instrument will not be used for evaluation of the site.

The analyzer will be calibrated at two week intervals during the field operations to ensure the safety of the sampling team during advancement of soil borings. The data from this instrument will not be used for evaluation of the site. Calibration of the flammable gas detector is based on measurement of a standard calibration gas mixture containing 2.5% methane (50% LFL) in nitrogen and oxygen. The reference gas is introduced to the sensor by way of the instrument's calibration adapter hose, and the LFL span screw is adjusted to indicate 50% LFL. The hose is removed, the display is allowed to return to 0% LFL, and the procedure is repeated.

Calibration of the hydrogen sulfide gas detector is based on measurement of a standard calibration gas mixture containing 25 ppm hydrogen sulfide in nitrogen. The reference gas is introduced to the sensor by way of the instrument's calibration adapter hose, and the H₂S span screw is adjusted to indicate 25 ppm. The hose is removed, the display is allowed to return to 0 ppm, and the procedure is repeated.

The oxygen sensor is calibrated using ambient air as the reference gas. The oxygen span screw is adjusted to indicate 20.9% when exposed to ambient air.

Portable Organic Vapor Analyzer

An HNU Systems Model PI-101 organic vapor analyzer will be used during portions of this RI project. Calibration will be performed at the beginning of each day with a standard calibration gas of a concentration within the expected range of use. Since the HNU instrument is projected for use only in the area of potential chlorinated solvent contamination, the calibration gas will consist of 25 ppm (50% TLV-TWA) trichloroethylene in organic-free air. The data from this instrument will not be used for evaluation of the site.

The carrier gas pressure and battery charge will be checked at the beginning of each day. The calibration gas canister will then be connected to the instrument, and the range switch will be set to the 0-200 range position. After introduction of the calibration gas, the span potentiometer will be adjusted to obtain an accurate reading. All calibration information will be recorded in a field log.

8.7.2 Laboratory Instruments

The calibration procedures and frequencies for laboratory instruments are described in the Contract Laboratory Program Statement of Work No. 887 for organic parameters (Appendix B) and in Statement of Work No. 787 for trace metals (Appendix B). Calibration procedures and frequencies for hexavalent chromium analyses are include in the SOP (Appendix B)

8.8 Data Reduction, Validation and Reporting

Data reduction, validation and reporting responsibilities for field activities and the overall project lies with the RI Project Manager and the QA/QC Officer. Initial data reduction, validation and reporting responsibilities for laboratory analysis data lie with ENCOTEC (chemical) and McDowell and Associates (geotechnical).

Data reports from field activities will include all raw data, appropriate reduction methods, and related QA/QC data. Data reports from analysis laboratories will include raw data, reduced data, and related QA/QC data. If data reduction methods are not specified in an SOP, or if SOP procedures are modified, the actual data reduction methodologies will be specified in all affected data reports.

The analysis laboratories will initially validate analysis results according to the established SOW for each analysis and the laboratory QA/QC procedures. If analysis procedures or results are found to be outside acceptable control limits, the affected sample analyses will be repeated. If repetitive analysis results are outside of control limits, the sample will be deemed unsuitable for the method. The RI Project Manager will then decide on the proper course of action.

Field and laboratory data will be validated by the QA/QC Officer after submission to the Project Manager. Raw data will be spot-checked for each parameter to inspect for transcription errors. The data will then be assessed by verification of the reduction results and confirmation of compliance with QA/QC requirements. This assessment will be performed by reviewing the following operations and data factors:

- Compliance with holding time requirements;
- Compliance with calibration procedures;
- Compliance with data reduction procedures;
- Laboratory control sample analyses;
- Compliance with QAPP accuracy and precision goals;
- Field and laboratory blank analyses.

Laboratory data will be validated according to the protocols specified in the following documents:

- "Laboratory Data Validation, Functional Guidelines for Evaluating Inorganic Analysis," May 28, 1985.
- "Laboratory Data Validation, Functional Guidelines for Evaluating Organic Analysis," May 28, 1985.
- "Laboratory Data Validation, Functional Guidelines for Evaluating Pesticides/PCBs Analysis," May 28, 1985 (Supplemented June 24, 1985).

Field data and the geotechnical data package will be appended to the RI report. All sample analysis results, precision and accuracy test results and blank analysis results will be reported. The laboratory data, following SOW 288 and SOW 788, will be reported using the data forms (1 through 10) for organics and forms (1 through 4) for inorganics. A copy of each of these forms is included in Appendix B. Raw data results (bench sheets, notes, chromatograms, etc.) will be maintained at ENCOTEC.

8.9 Internal Quality Control Procedures

Internal quality control procedures for laboratory analyses will be performed as specified in CLP SOW 288 for organic parameters and SOW 788 for metals parameters. These SOWs specify the requirements for analyses of method blanks, laboratory duplicates, method spikes, matrix spikes, matrix spike duplicates, etc. They also specify the compounds to be used for matrix and surrogate spikes and the quality control acceptance criteria for these audits. The QC specifications are summarized in Table 8-5.

Internal quality control requirements for the analyses of hexavalent chromium, ammonia, nitrate and nitrite are specified in the attached SOP's (Appendix C).

Field duplicates, field blanks and trip blanks will be collected as described in Table 8-3 to check the validity of laboratory data. QA checks of data processing will be performed by Dale

TABLE 8-5
LABORATORY QUALITY CONTROL PROCEDURES

<u>Parameter</u>	<u>Lab Blanks</u>	<u>Spikes or Surrogates</u>	<u>Spike or Lab Duplicates</u>	<u>Reference</u>
Base/Neutral Compounds	One per set of samples or a minimum of 1 in 10	Surrogates added to each sample and matrix spikes added to one sample per set or a minimum of 1 in 20	One per set of samples or a minimum of 1 in 20	Quarterly
Volatiles	One per day or 8-hour shift	Surrogates added to each sample and matrix spikes added to one sample per set or a minimum of 1 in 20	One per set of samples or a minimum of 1 in 20	Quarterly
Metals and Cyanide	One per 10 samples	One per 20 samples	One per 10 samples	Quarterly
Pesticide/PCB	One per set of samples or a minimum of 1 in 10	Surrogate added to each sample and matrix spikes added to one sample per set or a minimum of 1 in 20	One Spike Duplicate per set of samples or a minimum of 1 in 20.	Quarterly

Scherger of ENCOTEC (refer to ENCOTEC QA/QC Procedures attached in Appendix B). All data analyses and tabulations will also be checked by the Techna QA/QC Officer or his designated representative.

8.10 Performance and System Audits

The laboratory selected to perform chemical analyses for this project is subject to a performance and system audit by the Contract Laboratory Support Section (CLSS) of the Central Regional Laboratory (CRL), USEPA Region V.

The RI Program Manager or QA/QC Officer for Techna Corporation will be responsible for auditing the field team to ensure compliance with operating procedures, sample custody and QA/QC requirements. One full scale audit will be performed during the field investigation, and multiple, spot check audits of specific procedures may also be performed.

8.11 Preventative Maintenance

Field instrumentation scheduled for use during the RI includes the HNU Model PI-101 Organic Vapor Analyzer, Presto-Tek Model DspH-3 pH and specific conductivity meter, Gastech Model Gx-82 HS ambient gas analyzer and Omega Model HH-51 temperature meter. Specific preventative maintenance procedures and spare parts lists are available for reference on-site. It is the responsibility of the Field Team Leader to ensure adherence to these preventative maintenance procedures and schedules.

8.12 Specific Routine Procedures Used to Assess Data Precision, Accuracy and Completeness

Detailed procedures are presented in Section 8.3 and Appendix B of this document. It will be the responsibility of the Techna QA/QC Officer and the laboratory QA/QC officer to ensure that these procedures are followed.

8.13 Corrective Action

Corrective action that may be required during day-to-day field activities will be managed by the Field Team Leader in consultation with members of the field team. The team Leader will make immediate decisions with the team members with respect to new or modified protocols to be utilized. All changes in field procedures will be documented in a field logbook and reported in the succeeding monthly progress report and the final RI report.

Corrective actions for laboratory analyses will be implemented through consultations between the Techna QA/QC Officer and the laboratory QA/QC officer. The Project Manager will make immediate decisions on new protocols to be implemented after consultation with the Techna QA/QC Officer. All changes in laboratory procedures will be documented and reported in the laboratory report and the final RI report.

8.14 Quality Assurance Reports to Management

Monthly progress reports will be prepared by the Project Manager in consultation with the QA/QC Officer and Field Team Leader. These reports will include status summaries for the various project tasks, results of QA/QC audits conducted during the period, and any corrective actions implemented during the period. The final RI report will include a data quality assessment for all data generated during the RI project.

APPENDICES

APPENDIX A
REPORTS OF PRIOR INVESTIGATIONS

INTEROFFICE COMMUNICATION

REFERENCE

SITE NAME Hi-Mill ManufacturingSITE ID MEID005341714

To: Problem Evaluation Committee

Subject: Hi-Mill Manufacturing

From: Ron Willson, Biology Section

Date: March 1, 1978

Hi-Mill Manufacturing has an aluminum anodizing process and fabricates tubular aluminum and copper parts. Nitric acid, sulfuric acid and dichromate solutions are utilized. Lead has been used in the past. Process wastes are discharged to a seepage lagoon which is adjacent to a marsh tributary to Waterbury Lake.

In April, 1972 staff investigated a complaint by employees expressing concern that two wells providing drinking water within the plant were contaminated by the seepage lagoon. Elevated copper (0.38 mg/l) was found in the east well. All other parameters in both wells were normal. At the same time the adjacent marsh waters contained low pH and high levels of nitrates and copper.

Additional samples collected on October 9, 1975 showed high levels of nitrates, copper, aluminum, zinc and chrome in the marsh waters. Elevated nitrate, copper, nickel and aluminum in lake shore waters indicated movement of contaminants to Waterbury Lake.

A state groundwater permit was issued on October 31, 1975. Required monitoring wells were never installed. In Fall, 1976 a second lagoon was constructed without Water Quality Division approval. Direct overflows to the marsh occurred in December, 1976 and November, 1977.

A Notice of Noncompliance was issued on March 2, 1977 for failure to submit required monitoring reports. On March 15, 1977 the company was requested to apply for an NPDES permit. A proposed permit was issued on September 16, 1977. On November 18, 1977 U.S.-EPA informed the Water Quality Division that they could not concur with the issuance of an NPDES permit.

On December 13, 1977 Hi-Mills Manufacturing indicated an intent to implement a total recycle system and eliminate all waste discharges. A draft consent order requiring the elimination of all waste discharges, removal of lagoon waters and sludges and submission of a PIPP has been prepared and will be issued shortly.

Immediately following ice-out staff will sample company wells, lagoon waters and sludges, marsh waters and sediments and lake shoreline waters and sediments. Lagoon sample results will assist in assuring proper disposal of wastes in accordance with the proposed consent order. The well, marsh and lake samples are to broaden our information on previous ground and surface water contamination.

000001

STATE OF MICHIGAN



NATURAL RESOURCES COMMISSION

RL T. JOHNSON
I. LAITALA
IAN PRIDGEON
HILARY F. SNELL
HARRY H. WHITELEY
JOAN L. WOLFE
CHARLES G. YOUNGLOVE

WILLIAM G. MILLIKEN, Governor

DEPARTMENT OF NATURAL RESOURCES

STEVENS T. MASON BUILDING, LANSING, MICHIGAN 48926
HOWARD A. TANNER, Director

Pte. Mouillee State Game Area
Rt. #2, Rockwood, MI 48173

December 6, 1976

WATER RESOURCES COMMISSION

C. WILLIAM COLBURN
JOHN E. GLAB
CHARLES D. HARRIS
JOHN H. KITCHEL, M.D.
CLEAMON E. LAY
STANLEY QUACKENBUSH
JOHN E. VOGT

Mr. Robert F. Beard, President
Hi Mill Manufacturing Company
1704 Highland Road
Highland, MI 48031

Re: Status of Compliance
State Permit M00167

Dear Mr. Beard:

On December 2, 1976, Mr. Dennis Leonard inspected your seepage pond facilities and discovered that your new pond was overflowing to the marshy area adjacent to Waterbury Lake in section 23 of Highland Township. This overflow condition is in violation of section II.A. of State of Michigan permit No. M00167 issued to your company on October 31, 1975. Section II.A. states in pertinent part, "All liquid wastes.... if disposed of by impounding shall be confined within a designated area enclosed by dykes which are so constructed as to protect against loss or overflow of the contents to surface waters of the state...".

Analysis of a sample of the discharge to the swamp showed the following:

Total copper	-	4.8 mg/l
Total aluminum	-	25.0 mg/l
Total chromium	-	0.92 mg/l
Hexavalent Chromium	-	0.36 mg/l
pH	-	6.0

The above results indicate that the metallics contained in your waste are of sufficiently high concentration as to cause lethal effects on the fish and aquatic organisms in Waterbury Lake.

In addition to the above sample, we have collected samples from your ponds on two previous occasions in 1976. Results of analysis



R. F. Beard, President
Hi Mill Mfg. Co.
12/6/76

of those samples showed the following:

Parameter	Pond No. 1 5/21/76	Pond No. 1 11/19/76	Discharge to Pond No. 1 11/19/76
Total Copper (mg/l)	8.0	5.9	2.2
Total Chrome (mg/l)	2.2	1.1	0.94
Hexavalent Chrome (mg/l)	.01	0.14	0.60
Total Nickle (mg/l)	.05	---	---
Total Aluminum (mg/l)	14.0	44.0	15.0
NH ₃ -N (mg/l)	7.0	12.0	22.0
NO ₂ -N (mg/l)	---	1.2	0.07
NO ₃ -N (mg/l)	---	89.0	90.0
NO ₂ -NO ₃ -N (mg/l)	74.0	---	---
pH	3.3	5.4	5.6

The above analysis indicates that the concentrations of materials in your wastewater are consistently above what would be acceptable for a surface water discharge.

In addition to your violation of section II.A. of your permit, you are also in violation of section II.E.3. requiring the submittal and approval of a preliminary engineering report and basis of design on or before March 31, 1976. Your preliminary plan was rejected by letter of June 4, 1976, from our office in which we requested resubmittal with additional information. Your October 28, 1976, letter indicates that you chose to disregard our June 4 letter and proceeded to enlarge your existing lagoon and install a second lagoon without approved plans. Although your October 28 letter states "The area has been graded so that no direct loss or overflow of process wastes will flow to the adjoining swamp and lake", our observations do not bear out that this is in fact the case.

As a result of the above conditions at your facility, we are requesting that you or your designated representative attend a meeting at our offices at 10:00 a.m. on December 20, 1976. You or your representative should be prepared to present a definitive program, including a time schedule, for correction of the problems associated with your wastewater treatment facilities. If you should have any questions involving this correspondence please feel free to contact us at (313) 379-9692.

Very truly yours,

WATER QUALITY DIVISION

Roy E. Schrameck

Roy E. Schrameck
District Engineer

RES/jf
cc: John Bohunsky

000003

APRIL 1978

MDNR STUDY OF ADJOINING MARSH AREA

000004

STAFF REPORT

REFERENCE 11
SITE NAME Hi-Mill Manu
SITE ID WED005341714

Investigation of Hi-Mill Manufacturing Treatment Facility,
Vicinity of Highland, Michigan, April 26, 1978

On April 26, 1978, Water Quality Division (WQD) staff conducted an investigation of Hi-Mill Manufacturing's waste treatment facility at the request of John Bohunsky, Chief of Field Operations, Water Quality Division. Hi-Mill Manufacturing is an aluminum anodizing plant which fabricates tubular aluminum and copper parts. The objective was to assess the impact their waste lagoon overflow has had on an adjacent marsh. The company had planned to eliminate their lagoon by March, 1978, but at the time of the survey they had not implemented the closed cycle system.

Summary and Conclusions

1. At the time of the survey, there was a direct overflow to the marsh from the lagoon. Water and sediment samples were collected from the company's well, lagoon and various locations in the adjacent marsh (Figure 1).
2. The water chemistry data (Table 1) showed elevated levels of nitrate-nitrite, ammonia, copper, zinc, and aluminum at all stations except the well sample (HM-2). No contamination of the company's well was indicated, however, the phosphorus level (1.76 mg/l) was unusually high. The elevated levels were a result of the lagoon overflow.
3. Sediment data (Table 2) indicated extremely high concentrations of copper, aluminum, and total chromium. Moderately elevated levels of zinc and lead were found in the lagoon and marsh. Copper and aluminum are used extensively in the company's process. Chromium, copper, zinc, and lead values were much higher than background data collected from Pontiac Lake, Oakland County (Table 2). These contaminated sediments could be a threat to waterfowl and shorebirds feeding in the marsh.

Recommendations

1. Hi-Mill Manufacturing should cease its discharge to the marsh and implement their total recycle system.
2. Lagoon water and sludges should be properly removed and the lagoon filled with inert fill.

Sediment and Water Chemistry By: Environmental Services Laboratory

Field Work and Report By: James Grant, Aquatic Biologist
Richard Lundgren, Aquatic Biologist
Biology Section

000005

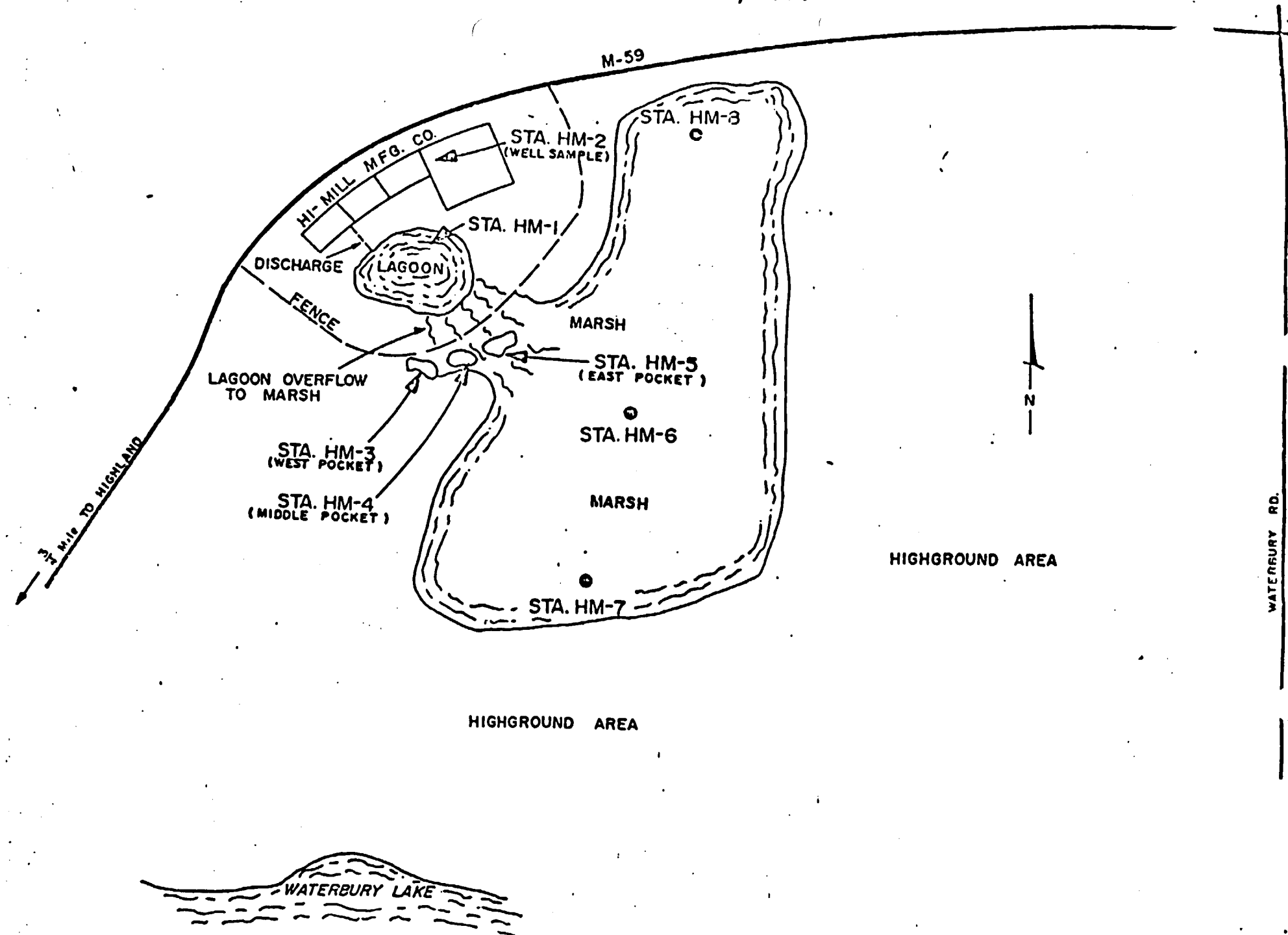


Table 1 Concentrations of selected parameters in water samples collected from Hi-Mill Manufacturing's well and lagoon and from the lagoon adjacent to the lagoon, vicinity of Highland, Oakland County, Michigan, on April 26, 1978. All values expressed in mg/l except pH.

Station Number	Station Location	<u>Parameters</u>												
		BOD	COD	pH	NO ₂ , NO ₃	NH ₃	Tot-P	SO ₄	Tot Cr	Cu	Hg	Pb	Zn	Al
1	Hi-Mill Lagoon Sample	7.2	27	4.9	160.	34.	0.88	128	4.0	30.	<.050	.070	14	60.
2	Hi-Mill Well Sample	-	18	7.7	0.03	0.19	1.76	14	<.010	.010	<.050	<.050	<.010	<1.0
3	West Pocket	-	-	7.1	33.	3.6	0.09	88	.060	.570	<.050	<.050	2.50	3.
4	Middle Pocket	-	-	6.2	16.3	2.5	0.07	64	.050	.580	<.050	<.050	.620	3.
5	East Pocket	-	-	7.4	152.	31.	0.12	140	.700	9.20	<.050	.070	8.90	34.
5	Middle of Marsh	-	-	7.7	11.1	1.51	0.07	56	.010	.440	<.050	<.050	2.20	2.0

Table 2 Concentrations of selected parameters in sediments collected from Hi-Mill Manufacturing's lagoon and from the marsh adjacent to the lagoon on April 26, 1978 in the vicinity of Highland, Oakland County, Michigan. All values expressed in mg/kg except PCBs which are given in µg/kg (dry weight).

Station Number	Station Location	<u>Parameters</u>								
		TOT-Cr	Cu	Ni	Pb	Zn	Al	PCB 1242	PCB 1254	PCB 1260
HM-1	Hi-Mill Manufacturing Lagoon	2200	7800	43	110	650	29,000	<500	<500	<500
HM-3	West Pocket	310	2700	67	22	1700	51,000			
HM-4	Middle Pocket	1200	2300	52	37	120	27,000			
HM-5	East Pocket	570	5200	59	43	2000	51,000			
HM-6	Middle Marsh	1400	14,000	54	62	540	38,000			
HM-7	South end Marsh	870	21,000	53	110	1100	28,000			
HM-8	North end Marsh	8500	51,000	35	170	480	32,000			
Control	Pontiac Lake *	5.8	0.8	22	58	68				

Unpublished data - Water Quality Division, MDNR - 1977

000008

AUGUST 1982
MDNR HYDROGEOLOGICAL STUDY

000009

REFERENCE 1
SITE NAME High-Mill Manu.
SITE ID ME D005341714

JAN 1

A Hydrogeological Study of the Vicinity of
HiMill Manufacturing, Highland, Michigan

Water Quality Division
Groundwater Unit
Kathleen Sibb, Geologist
August 31, 1982

000010

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Appendix

Well Records

Summary

The HiMill Manufacturing Company, located on M-59 in Highland, Michigan, Oakland County, T3N R7E Section 23, makes fabricated tubing and fittings using copper or aluminum tubing (Legrand assessment July 29, 1980). The HiMill property borders on the Highland State Recreation Area. The HiMill lagoon is adjacent to a marsh connected to Waterbury Lake.

Wells were installed in the Highland Recreation Area outside the eastern and southern fence line of HiMill Manufacturing to determine if heavy metals were leaching from the HiMill lagoon into the adjacent marsh. Elevated levels of aluminum, copper, chromium and zinc were detected to the east and south-east of the lagoon. Somewhat less elevated levels of these metals were detected to the north-east of the lagoon, near the edge of the HiMill parking lot. Each of these wells was in or adjacent to the marsh and in the direction of groundwater flow from the HiMill property to the marsh.

Procedure

A preliminary site inspection was made on July 9, 1980 at the HiMill Manufacturing Company on M-59 in Highland, Michigan, which produces fabricated tubing and fittings (Legrand assessment, July 29, 1980). The inspection included some hand augering to determine the types of sediment on the site.

The wells were installed on May 18, 1981. The boreholes were hand-augered and the wells were installed to a maximum depth ranging from 3.84 to 6.9 feet. The wells were constructed of 1-1/4 inch I.D. schedule 80 PVC casing with 3 foot long size 7 slot PVC screens. The well annuli were packed to above the screen with #3 silica sand from the Gibraltar Corporation. Bentonite pellets or powdered bentonite was used to complete the filling to the ground surface (see appendix).

The wells were sampled on May 19, 1981, using a hand-operated diaphragm pump. The wells were pumped dry, rinsed with a small amount of Lansing city water and pumped dry again to help clear them. They were then allowed to re-fill before being sampled. Lansing city water was also pumped through the pump and hose to rinse them between the pumping of individual wells. Samples were taken for totals of chromium, copper, nickel, lead, zinc, and aluminum and were preserved and cooled according to MDNR Environmental Laboratory procedures. Water levels were measured by chalked tape on June 23, 1981 (see Table 1) and the site was mapped by the MDNR Engineering Division.

Geology and Ground Water Flow

The project site consists of relatively pure, dense clays and thin layers of sandy or gravelly clays. These generally are the result of water deposition and indicate a low permeability clay. This low permeability was observed during sampling by the slowness with which water entered the wells.

The top of the water table is at the ground surface in the vicinity of well HM3, approximately 35 feet east of the lagoon, at an elevation of 1006.0 feet. Ground water flow on the site is east, southeast, and south from the HiMill property into the adjacent marsh (see Table 1 and Figure 1).

Sampling Results

The location of well HM6 southwest of the lagoon was chosen for use as a background well since according to water table measurements it appeared to be out of the influence of drainage from the lagoon. Sampling results confirmed this since the metals concentrations of the water in HM6 were substantially lower than the highest metals concentrations and less than or equal to the lowest metals concentrations of water in the other wells (see Table 2).

The total chromium concentrations of the water in the wells varied from less than 50 ug/l to 160 ug/l (see Table 2 and Figure 2). The two wells with the highest chromium concentrations, HM3 with 160 ug/l and HM4 with 130 ug/l, lie to the east of the HiMill lagoon. The third highest, well HM1 east of the edge of the parking lot, had a chromium concentration of 110 ug/l.

The aluminum concentrations of the well water samples ranged from 1800 ug/l to 7900 ug/l (see Table 2 and Figure 3). Well HM5 southeast of the lagoon had the highest aluminum concentration; 7900 ug/l. The two wells with the next highest aluminum concentrations were HM1, east of the edge of the parking lot, with a concentration of 4600 ug/l, and HM3, east of the lagoon, with a concentration of 4000 ug/l.

The copper concentrations of the water in the wells varied from 30 ug/l to 840 ug/l (see Table 2 and Figure 4). The well with the highest copper concentration, 840 ug/l, was HM4 southeast of the lagoon. The two next highest copper concentrations were 480 ug/l in HM3 east of the lagoon, and 230 ug/l in HM1 east of the edge of the parking lot.

The zinc concentration of the well water samples ranged from less than 50 ug/l to 240 ug/l (see Table 2 and Figure 5). Well HM3 east of the lagoon with 240 ug/l was the well with the highest zinc concentration. The next highest zinc concentration was 110 ug/l in HM1 east of the edge of the parking lot.

Conclusions

The aluminum concentration was approximately 4.4 times higher in well HM5 and approximately 2.6 times higher in well HM1 than in background well HM6. The zinc concentration was approximately 4.8 times higher in well HM3 and at least 2.2 times higher in well HM1 than in background well HM6. The total chrome concentration was 3.2 times higher in well HM3, less than 2.6 times higher in HM4, and more than 2.2 times higher in HM1 than in well HM6. The copper concentration was 28 times higher in HM4, 16 times higher in HM3, and approximately 7.7 times higher in HM1 than in the background well HM6.

This information combined with measurements of the top of the water table (see Figure 1) indicate that copper, aluminum, chromium, and zinc are leaving the HiMill plant site in the ground water and are flowing into the adjacent Highland Recreation area. Most of the metals are migrating east and east-southeast from the lagoon area and were detected by wells HM3 and HM4. Some of the metals are migrating from the northeast end of the plant site and were detected by well HM1 near the edge of the parking lot. Aluminum and small amounts of chromium, copper, and zinc are migrating southeast from the lagoon area and were detected by well HM5.

Project Personnel

Geologist:	Kathleen Sibo
Driller:	Charles Ingalls
Driller's Assistant:	Jerry Parish
Supervisor:	Elmore Eltzroth
Surveyor:	Gary Bilow, MDNR Engineering Division
Analysis:	MDNR Environmental Laboratory
Drafting:	Gary Taylor, MDNR Engineering Division

Table 1 Well Elevations and Water Elevations in Feet; HiMill Inc. Vicinity
June 23, 1981

Well	Elevation Top of Casing	Elevation Ground	Height of Casing	Depth to Water	Elevation Water
HM1	1007.53	1006.5	1.03	1.62	1005.91
HM2	1007.07	1006.0	1.07	1.75	1005.32
HM3	1010.16	1006.0	4.16	4.7	1006.0
HM4	1009.58	1006.2	3.38	4.21	1005.37
HM5	1010.40	1006.4	4.0	4.64	1005.76
HM6	1011.09	1009.9	1.19	3.35	1007.74

Elevations are based on MDOT Bench Mark 156A.

KHS 1982

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Table 2 Metals Content of Water Samples, HiMill Vicinity - May 19, 1981

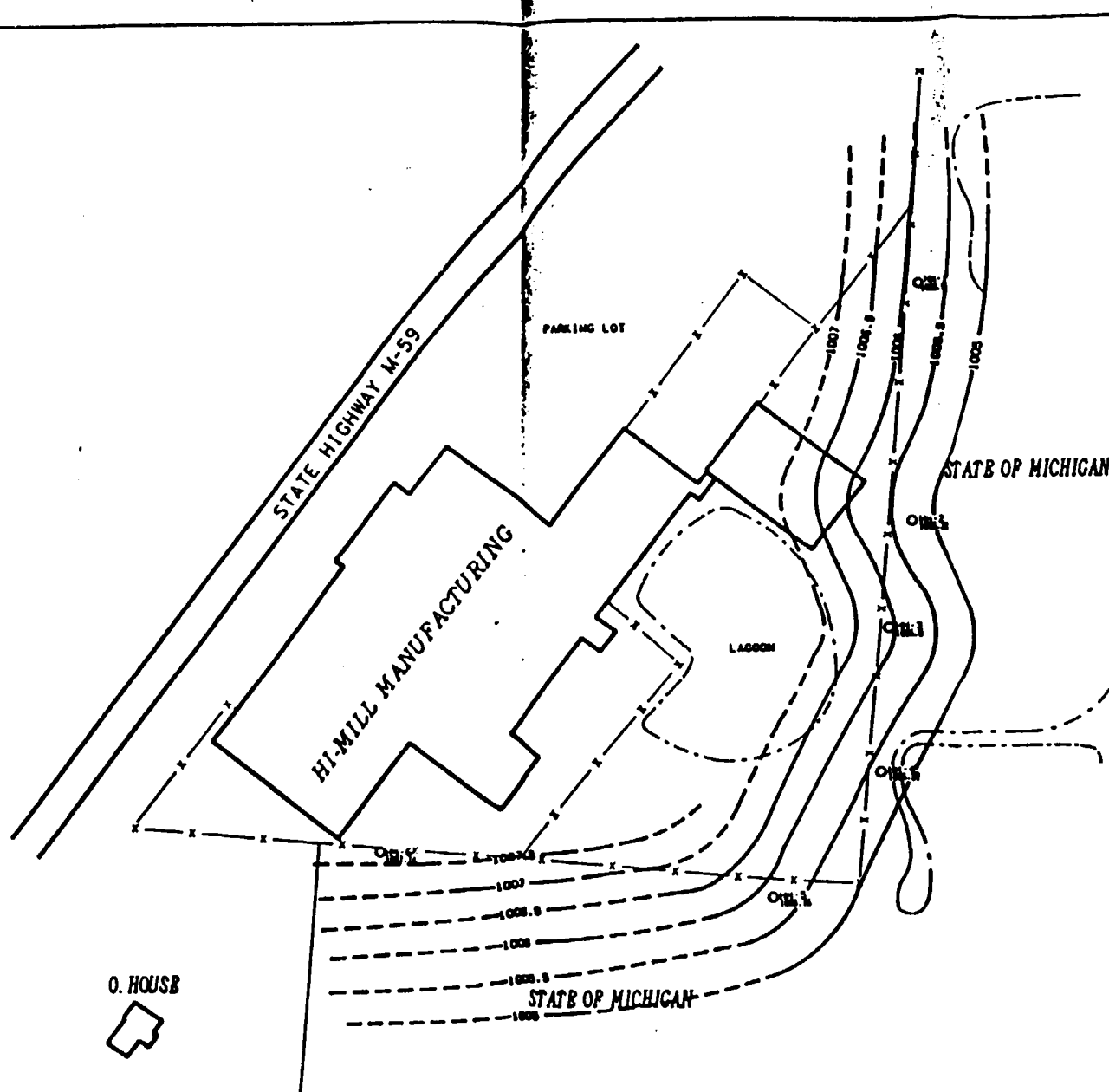
Well	Depth (feet)	Total Cadmium (ug/l)	Total Chromium (ug/l)	Total Copper (ug/l)	Total Nickel (ug/l)	Total Lead (ug/l)	Total Zinc (ug/l)	Total Aluminum (ug/l)
HM1	6.9	K 20	110	230	K 50	K 50	110	4600
HM2	6.9	K 20	80	30	K 50	K 50	60	2500
HM3	3.84	K 20	160	480	K 50	K 50	240	4000
HM4	4.62	K 20	130	840	K 50	K 50	K 50	3000
HM5	4	K 20	K 50	90	K 50	K 50	70	7900
HM6	6.81	K 20	K 50	30	K 50	K 50	K 50	1800

Note: Depth is measured from ground level to the bottom of a three foot screen.
K = Actual value is less than value given.

- PLANTERY IS TRACED FROM MICHIGAN DEPARTMENT OF TRANSPORTATION PLANS FOR M-59 CONSTRUCTION AND PLOTTED FROM FIELD MEASUREMENTS.
- PROPERTY LINES ARE APPROXIMATE.
- OWNERSHIP TAKEN FROM OAKLAND COUNTY TAX RECORDS.

E.M.S. 1982

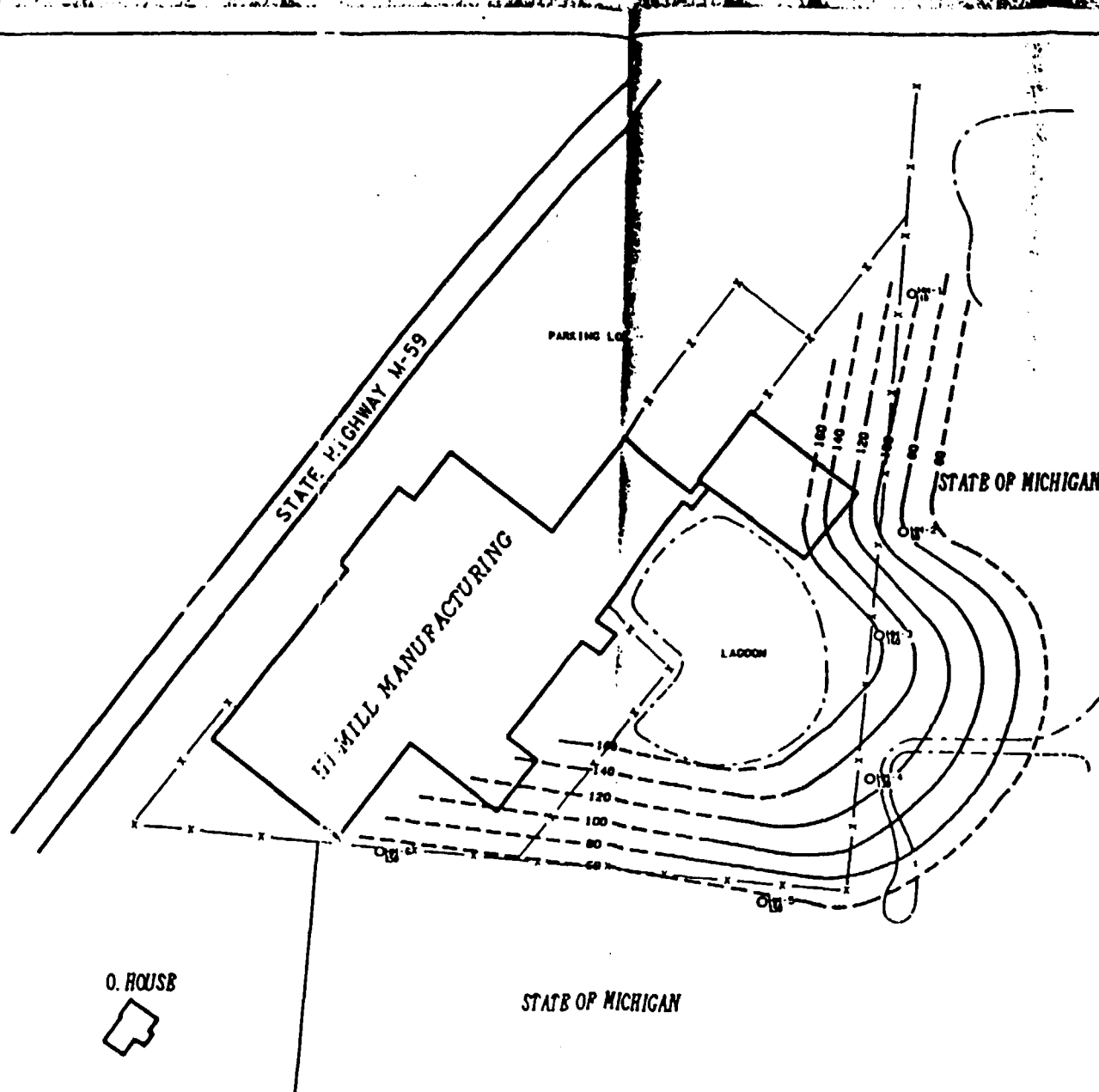
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— x — FENCE
- - - WATER LINE



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- PROPERTY LINES ARE APPROXIMATE.
- OWNERSHIP TAKEN FROM OAKLAND COUNTY TAX RECORDS.

E.M.S. 1902

001 GROUNDWATER TEST WELL
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- - - WATER LINE



O. HOUSE

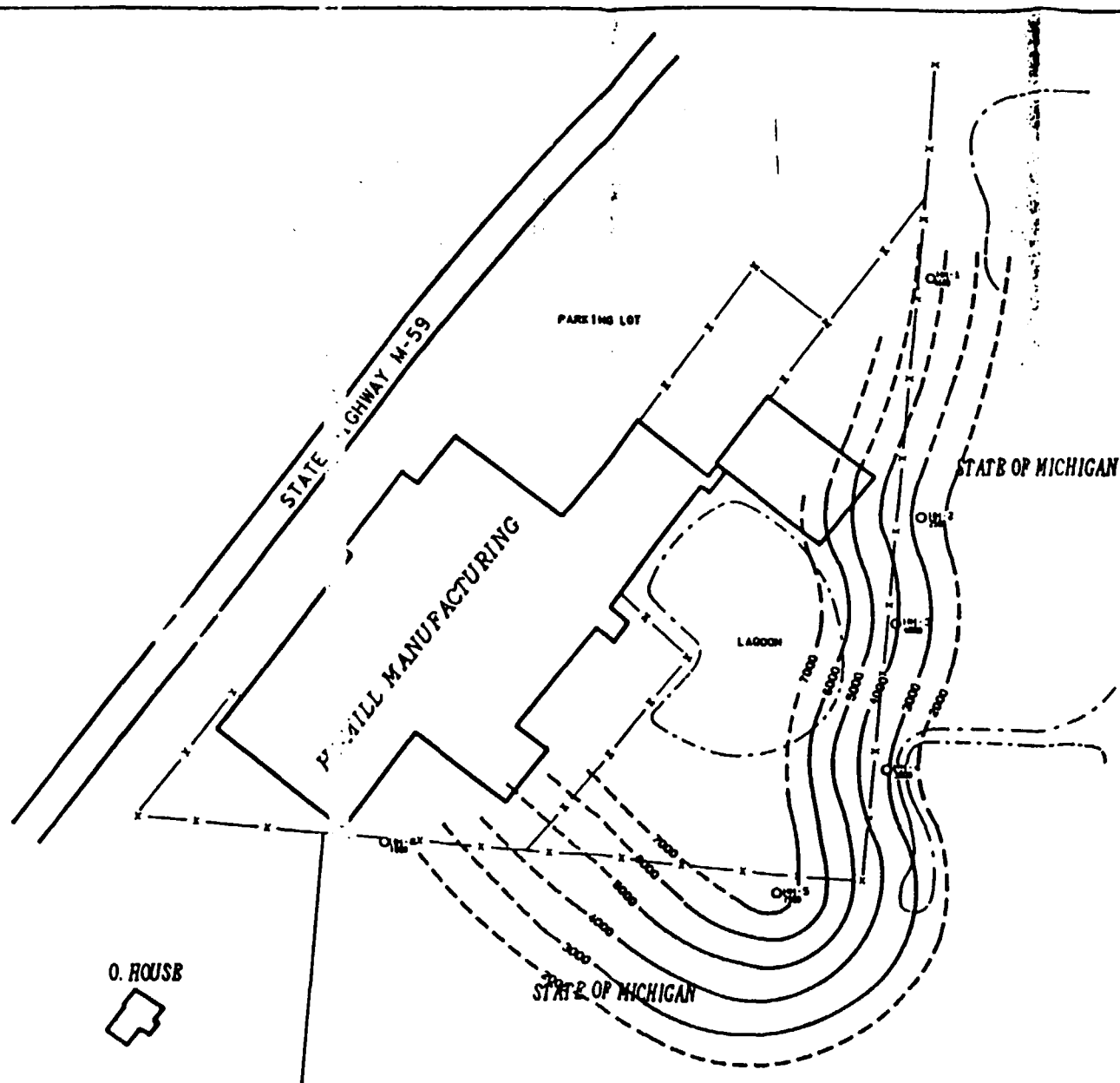
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- PROPERTY LINES ARE APPROXIMATE.
- OWNERSHIP TAKEN FROM OAKLAND COUNTY TAX RECORDS.

E.M.S. 1962

001 GROUNDWATER TEST WELL
— X — FENCE
- - - WATER LINE



O. ROUSE

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- PLANIMETRY IS TRACED FROM MICHIGAN DEPARTMENT OF TRANSPORTATION PLANS FOR M-59 CONSTRUCTION AND PLOTTED FROM FIELD MEASUREMENTS.
- PROPERTY LINES ARE APPROXIMATE.
- OWNERSHIP TAKEN FROM OAKLAND COUNTY TAX RECORDS.

E.M.S. 1902

010-1 GROUNDWATER TEST WELL

— X — FENCE

WATER LINE

O. HOUSE

STATB OF MICHIGAN



SCALE

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Appendix

CONCRETE SETTING UNIT TEST WELL RECORD

PLAT NO.
791-312-463

PROJECT: Hi-Mill vicinity

NO. 4M2

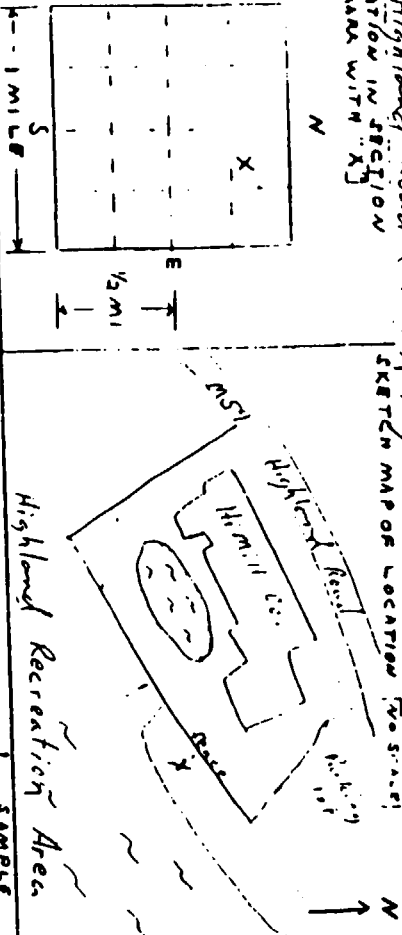
SECTION

TOWNSHIP AND RANGE

FRACTION SE 1/4 NW 1/4 NE 1/4

ST ADDRESS AND CITY OF WELL LOCATION

Highland Road (MS9), Highland
SECTION IN SECTION WITH "X"



PTM	THICKNESS OF STRATA	DESCRIPTION	SAMPLE IDENTIFICATION NO.	TYPE
-----	---------------------	-------------	---------------------------	------

7' 7' Clay, grey

SECTION NO. 23 TOWN 13N RANGE 7E ELEV 87E

PROPERTY OWNER STATE OF MICHIGAN
ADDRESS Highland State Recreation Area
Highland Road
Highland, ME. 48031

WELL DEPTH (COMPLETION) DATE OF COMPLETION
6.9 ft 5/13/81

DRILLING METHOD(S) DEPTH(S)

3" hole auger 7 feet
CASING: DIAMETER 1 1/4 IN. TO 3.9 FT. DEPTH 1.62 FT
IN. TO FT. DEPTH TYPE PVC WEIGHT 33 LB. DC

SCREEN: PVC DIAM. 1 1/4
TYPE

SLOT/AUGER 7 slot LENGTH 3 ft.
SET BETWEEN 3.9 FT. AND 6.9 FT.

WATER LEVEL: AT BELOW SURFACE
FIRST NOTED AT

AFTER COMPLETION 6.25 FT BELOW
SURFACE OR CASING TOP

SURFACE ELEVATION 1006 ft.

SEALING METHOD Sand packed to within
2'3" of top, powdered bentonite to the
surface
= NEW Driller Charles Ingalls
Driller's Assistant Jerry Perovich
Geology ST Kathleen Sibo
RECORDED BY Kathleen Sibo
DATE 6/26/81
REMARKS

PLUGGING AND ABANDONMENT METHOD

000025

DATE
CRAW

ENVIRONMENTAL SENSITIVE LAND AREA GROUNDWATER INVESTIGATION UNIT TEST WELL RECORD

SIT. NO. HM3

PROJECT: Hi-Mill vicinity

PPAT F. NO. 791-812-463

LOCATION ON 0.1 mi. SW 1/4 NW 1/4 NE 1/4
 TOWNSHIP Highland RANGE SW 1/4 NW 1/4 NE 1/4
 SECTION 23 T3N R7E E1A
 PROJECT: Highland
 ADDRESS: Highland State Recreation Area
 WELL DEPTH (COMPLETED) DATE OF COMPLETION 3.84 ft. 5/14/81
 CRILLING METHOD(S) 3" hand auger
 CASING: DIAMETER 1 1/4 IN. TO .84' FT. DEPTH WEIGHT 4 lb
 ABOVE SURFACE 4.16 FT

Sketch map of location showing Highland Rd, Hi-Mill Co, and the test well location. A north arrow points up. A scale bar indicates 1/2 mile.

DEPTH IN FOOT	DESCRIPTION	SAMPLE IDENTIFICATION NO.	TYPE
3' 3"	Clay		
3' 6"	Clay, gravelly, sandy		
4' 6"	Clay		

SCREEN: PVC DIAM. 1 1/4"
 SLOT/GAUZE 7 slot LENGTH 3 ft.
 SET BETWEEN .84 FT. AND 3.84 FT.
 WATER LEVELS 21 AT BELOW SURFACE
 AFTER COMPLETION 4.7 FT BELOW
 SURFACE, OR CASING TOP
 SURFACE VARIATION 1006 ft.
 SEALING METHOD Sand packed to with
2 in. of surface, then filled to surface
with powdered bentonite, & bentonite pills
 CREW Driller Charles Ingalls
 Driller's Assistant Jerry Parrish
 Recorder Kathleen Sibo
 DATE 6/24/81
 REMARKS Kathleen Sibo

PLUGGING AND ABANDONMENT METHOD

0000026

DATE
CREW

PROPOSED SEINFELT UNIT TEST WELL RECORD

NO. HMY

PROJECT: Hill Country

PLAN NO. 791-812-463

C ON

On land

TEST ADDRESS AND CITY OR WELL LOCATION

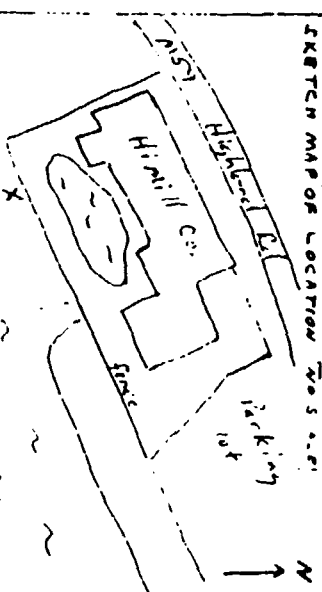
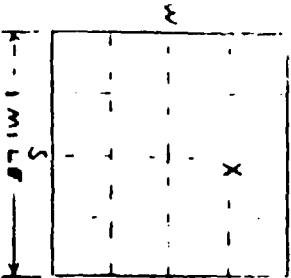
Highland

SECTION S1/4 NW 1/4 NE 1/4

SECTION NO. 23 TOWN T3N R. R7E E. 1

Highland Road (MS9) Highland
SECTION IN SECTION
[MARK WITH "X"]

N



DEPT. TO MEASURE IN FEET DESCRIPTION SAMPLE IDENTIFICATION NO. TYPE

2'	2'	Clay	
4'	2'	Muck, dark, with sand and some clay and gravel.	
	1'	clay	

OWNER'S name State of Michigan
ADDRESS Highland Road, Highland, MI.
WELL DEPTH (corrected) DATE OF COMPLETION
4.62 ft. 5/18/81
CALLING METHOD(S) DEPTH(S)

3" hand auger 5 feet
CASING: DIAMETER 1 1/2 IN. TO 1.62 FT. DEPTH 3.32 FT
IN. TO FT. DEPTH TYPE PVC
WEIGHT 30

SCREEN: PVC DIAM. 1 1/2"
SLOT/SAUCE 7 slot LENGTH 3 ft.
SET BETWEEN 1.62 FT. AND 4.62 FT.
WATER LEVELS 1 AT BELOW SURFACE
FIRST NOTED AT 1 AT BELOW SURFACE
AFTER COMPLETION 4.21 FT BELOW
SURFACE OR CASING TOP
SURFACE ELEVATION 1006.2

SEALING METHOD Sand packed to within 2-3 in. of surface, then bentonite pellets to surface.

CREW Driller Charles Ingalls
Drivers ASS. s from Terry Arrish
Geologist Kaileen Sibley
RECORDED BY Kaileen Sibley
DATE 6/26/81
REMARKS

PLUGGING AND ABANDONMENT METHOD

000027

DATE

TEST WELL RECORD

WELL NO.

HMS

PLOT NO.

791-812-463

PROJECT: HILL. Vicinity

LOCALITY

TOWNSHIP NAME

Highland

SECTION

SW 1/4 NW 1/4 NE 1/4

SECTION NO.

23

TOWN

T3N

RANGE

R7E

E1/4

BEST ADDRESS AND CITY OR WELL LOCATION

Hill and

Highland State Recreation Area

Highland Road (MS9) Highland

SECTION IN SECTION

(AREA WITH "X")

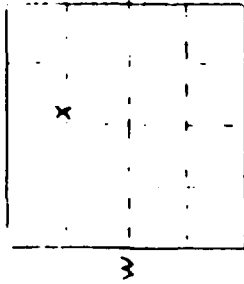
SKETCH MAP OF LOCATION (SEE SKETCH)

PLOT NO.

1

N

↑



1/4 MILE

Highland Recreation Area

DEPTH IN FEET

2"

2"

4'

3'

10"

Clay, dense grey-brown

Top soil

DESCRIPTION

SAMPLE NO.

TYPE

1006.4

PVC

DIAM. 1 1/4"

LENGTH 3 ft.

SET BETWEEN 1 FT. AND 4 FT.

WATER LEVELS

FIRST NOTED AT

AT BELOW SURFACE

AFTER COMPLETION 4.64 FT BELOW

SURFACE OR CASING TOP

SURFACE ELEVATION

1006.4

SEALING METHOD Sand pack to within

a few inches of surface, bentonite pellets

and powdered bentonite to surface.

CREW Driller Charles Ingalls

Driller's Assistant Jerry Parrish

Geologist Kathleen Sibbo

RECORDED BY Kathleen Sibbo

DATE 6/26/81

REMARKS

PLUGGING AND ABANDONMENT METHOD

000028

DATE
CREW

APRIL 1984

MDNR BIOLOGICAL, SURFACE WATER AND SEDIMENT SURVEY

000029

REFERENCE

10

SITE NAME

Hi-Mill Kanny

SITE ID

MID005341714

RECEIVED

MAR 06 1985

WATER QUALITY DIV.
DIST. I

Michigan Department of Natural Resources
Surface Water Quality Division
Water Quality Surveillance Section
February 1985

A Biological and Water and Sediment Chemistry Survey
of Waterbury Lake and Adjacent Marsh
Oakland County, Michigan
April 26, 1984

Introduction

Surface Water Quality Division staff of the Water Quality Surveillance Section surveyed Waterbury Lake and a marsh east of Hi Mill Manufacturing Company to determine the potential impact of Hi Mill Manufacturing Company discharge on these water bodies (Figure 1). The survey was performed at the request of Hakim Shakir, Detroit District Groundwater Quality Division staff in connection with the groundwater cleanup operation at Hi Mill Manufacturing.

Conclusions

1. Waterbury Lake was not connected with the marsh east of Hi Mill Manufacturing and was not impacted by Hi Mill Manufacturing surface water discharges.
2. Marsh waters generally contained higher concentrations of heavy metals than the background stations in Waterbury Lake.
3. Concentrations of copper in marsh waters exceeded the chronic criteria for warmwater species of freshwater aquatic life.
4. Sediment heavy metal concentrations in the marsh exceeded background concentrations in Waterbury Lake and in many cases mean concentrations downstream of industrial and municipal discharges.
5. Algae and zooplankton were abundant in marsh waters but bottom dwelling organisms were limited to pollution tolerant forms. The lack of additional species may be due to limited water in the dry season or the nutrient enriched condition of the marsh waters.

Recommendations

1. Minimize the sources of heavy metals entering the marsh from the Hi Mill parking lot and roof drainage system.
2. Continue to fill the existing lagoon.
3. Determine if contaminated groundwater should be purged.

000030

Background

Hi Mill Manufacturing has an aluminum anodizing process and fabricates aluminum and copper parts. Process wastes are discharged to seepage lagoons adjacent to the marsh east of their property. In 1972 elevated levels of copper were found in the adjacent marshland and one of the company's drinking water wells (SWQD File, Hi Mill Mfg. Co.). In 1975 additional water samples collected in the marsh revealed elevated concentrations of nitrates, copper, aluminum, zinc and chromium. File reviews showed lagoon overflows had apparently been occurring and in April of 1978 additional water and sediment sampling was completed in the lagoon and marsh. Recommendations were made to remove lagoon wastes and sludges and fill the lagoon (Grant, 1978). None of the recommendations were accomplished, but no additional discharges were made to the lagoon after 1978. Hi Mill Manufacturing attempted to evaporate the lagoon liquid by spraying it into the air from the top of their building. This resulted in liquids entering the marsh through their roof and parking lot drain system. Groundwater samples collected in 1981 showed migration of elevated concentrations of aluminum, chromium, copper and zinc in the shallow water table (3 to 7 feet) and into the marsh (Sibo, 1982). As of November 1983, lagoon liquids and sludges had been removed and the lagoon itself was being filled.

Methods

Water and sediments for chemical analysis were collected and preserved according to "Quality Assurance for Water and Sediment Sampling" (MDNR 1981) and returned to the Environmental Laboratory in Lansing for analysis. Benthic macroinvertebrates were collected with a petite ponar dredge grab sampler and sieved through a number 30 mesh sieve. Organisms were identified with the naked eye on site and their abundance qualitatively assessed and recorded on stream problem assessment cards (Appendix A). Phytoplankton samples were qualitatively collected with a 64 micron mesh phytoplankton net towed at approximately a 45 degree angle, washed into a vial and returned to the Lansing Biological Laboratory and identified under the microscope at 400x power.

Water

Marshwater samples collected in 1984 contained lower concentrations of heavy metals than marshwaters at similar areas in 1978. However, concentrations of zinc, chromium, and copper were greater than those at the background location sampled in nearby Waterbury Lake. These data suggest that while heavy metal concentrations are decreasing in the marsh water they may still be leaching from the sediments into the water or continuing to enter from surface water discharges or contaminated groundwater. Neither chromium or zinc exceeded the criteria for freshwater aquatic life but the concentration of copper in the marsh water exceeded the chronic criteria (33 ug/l) for warmwater fish. Concentrations of total copper, zinc, chromium, and aluminum in the parking lot and roof

drainage were lower than the mid-marsh samples taken in 1978, but higher than marsh samples collected in 1984 indicating a continuing source of metals to the marsh. The copper concentration in the parking lot and roof drainage water exceeded both the acute and the chronic criteria for aquatic life. Contaminated groundwater resulting from the old seepage lagoons may also be contributing to heavy metals concentrations in marsh waters.

Sediments

Heavy metals in marsh and parking lots and roof runoff drainage sediments were higher than sediments collected in nearby Waterbury Lake Station 4 (Table 2). Total aluminum, total copper, total zinc and total cadmium were an order of magnitude higher while total chromium was two orders of magnitude higher in the marsh than in Waterbury Lake. These data suggest direct inputs of these metals to the marsh system from Hi Mill Manufacturing Company. Sediment total iron, total arsenic, total lead, total manganese and total lithium were also higher in the marsh than in Waterbury Lake. Mercury was detected only in the parking lot and roof drain outfall sediments. Concentrations of heavy metals in the marsh exceed the average concentrations downstream of industrial and municipal locations (Hesse and Evans 1972). It is not known if these sediment metals are leaching into the water column or are causing toxicity to aquatic insects, but bottom dwelling aquatic organisms were limited to tolerant midges in the marsh.

Aquatic Organisms

Only midges were found in the ponar grab samples collected in the marsh. These organisms are generally considered pollution tolerant. No other benthic aquatic insects were noted. The limited bottom dwelling community may be due to marsh water fluctuation (i.e., it may dry up in the summer) or it may be due to elevated concentrations of one or more heavy metals. Zooplankton were present at Stations 1 and 2. Daphnia sp. were very abundant at Station 2 nearest the old lagoon discharge where concentrations of copper in the water exceeded the criterion for aquatic life. It may be that these organisms blew in from another part of the marsh where copper was less concentrated. Other possibilities are that organic materials in the water column bound these copper molecules or that hardness and pH conditions created conditions reducing its toxicity. Daphnia are generally considered sensitive to relatively low copper concentration (Creal and Basch, 1981).

Only one fish was seen. A mudminnow was present near the outlet from the parking lot and roof runoff drainage system. The fish was dead with no evident cause. Mudminnows are tolerant of a wide variety of environmental conditions.

The presence of a variety of filamentous (Spirogyra) green algae, flagellates (Euglena) and other algae (Scenedesmus) Oocystis, Synedra, Oscillatoria and Mougeotia) and macrophytes (Typha, Scirpus, Lemna minor, Elodea and Potamogeton) indicated that the discharge did not have much impact on these aquatic plants (Table 3).

Literature Cited

Creal, W. and R. Basch. 1981, Water quality-Based Effluent Limits for Heavy Metals and Cyanide, MDNR, 124 p.

Environmental Protection Bureau, Michigan Department of Natural Resources, 1981, Quality Assurance Manual for Water and Sediment Chemistry.

Grant, 1978, Investigation of Hi Mill Manufacturing Treatment Facility, Vicinity of Highland, Michigan, April 26, 1978.

Hesse, J. N., and E. Evans, 1972, Heavy Metals of Surface Water, Sediments and Fish in Michigan. Michigan MDNR, 58 pp.

Sibo, K., 1982. A Hydrogeological Study of the Vicinity of Hi Mill Manufacturing, Highland, Michigan Department of Natural Resources.

Surface Water Quality Division Files for Hi Mill Manufacturing. MDNR.

**Survey By: John Wuycheck, Aquatic Biologist
Dave Kenaga, Aquatic Biologist**

Lab Analysis By: Environmental Lab

Algal Analysis By: Carey Johnson

**Report By: David Kenaga, District Aquatic Biologist
Michigan Department of Natural Resources
Water Quality Surveillance Section
Surface Water Quality Division**

Figure 1.

LOCATION OF SURFACE WATER AND ...
Company, Oakland County, Michigan, April 26, 1984.

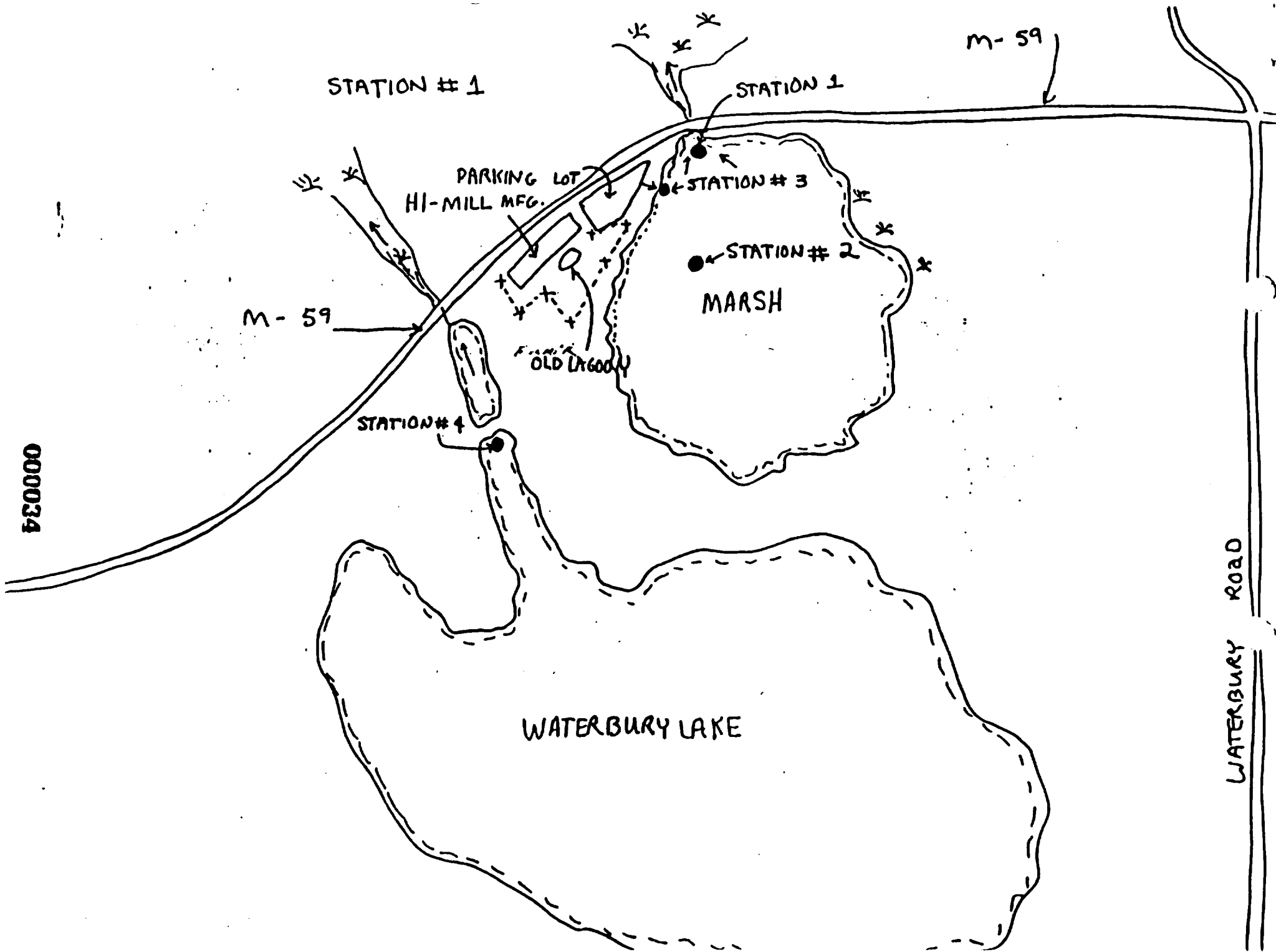


Table 1. Concentrations of selected heavy metals in water in the vicinity of Hi-Mill Manufacturing Company, April 26, 1984. Results in $\mu\text{g/l}$. (1978 Results from Grant 1978)

Location Sampled	Total Aluminum	Total Arsenic	Total Iron	Total Mercury	Total Zinc	Total Cadmium	Total Chromium	Total Copper	Total Nickel	Total Lead
At M-59 Marsh outlet	<400	<0.5	150	<0.5	23	0.2	2.8	48	<4	2.5
Mid Marsh East of building	<400	<0.4	120	<0.5	22	<0.2	6.5	200	<4	<2.0
Roof and parking lot runoff	964	1.3	914	<0.5	70	0.6	24	560	<4	<2.0
Outlet from Waterbury Lake	-	3.6	-	<0.5	-	<0.2	<2	3	<4	<2.0
Middle of Marsh (1978)	2000	-	-	-	2200	-	10	440	<50	<50

le 2. Concentrations of selected heavy metals in sediments in the vicinity of Hi-Mill Manufacturing Company, April 26, 1984. Results in mg/kg dry weight.

Location Sampled	Total Aluminum	Total Arsenic	Total Iron	Total Mercury	Total Zinc	Total Cadmium	Total Chromium	Total Copper	Total Nickel	Total Lead	Total Manganese	Total Solids	Total Lithium
M-59 marsh outlet	29,200	7.5	19,900	<0.5	1,800	11.0	2,350	10,000	50	269	360	13	-
Marsh west of building	16,100	4.2	15,600	<0.5	1,500	8.5	5,300	5,650	19	84	130	24	90
Parking lot and roof runoff	11,890	5.8	17,700	0.7	1,700	11.0	2,240	4,700	18	97	380	32	90
Outlet from Waterbury Lake	7,190	5.5	10,100	<0.5	150	<2.0	50	155	13	91	150	14	15

Table 3.

Aquatic plants found in the Marsh, east of Hi-Mill Manufacturing Company,
Oakland County, Michigan, April 26, 1984.

Algae	Macrophytes
<u>Spirogyra</u>	<u>Typha</u>
<u>Euglena</u>	<u>Scirpus</u>
<u>Scenedesmus</u>	<u>Lemna minor</u>
<u>Oocystis</u>	<u>Elodea</u>
<u>Oscillatoria</u>	<u>Potamogeton</u>
<u>Mougeotia</u>	
<u>Synedra</u>	

MICHIGAN DEPARTMENT OF NATURAL RESOURCES
WATER QUALITY DIVISION

BIOLOGY SECTION
STREAM PROBLEM ASSESSMENT

Station Number 1 Investigator(s) Kenaga, Wuycheck
Date 4 / 26 / 84 TIME 11:30 am PHOTOGRAPH NUMBER _____
BODY OF WATER Marsh east end of Hi-Mill LOCATION near outlet under M-59, 15' fr. north shore
COUNTY Oakland ^{MFG.} Twp R 7E S 23 TWP Highland
REASON FOR SURVEY Hi-Mill Mfg.

VICINITY LAND USE: Mostly Forest Mostly Urban Mostly Agriculture Other _____
AVE. STREAM WIDTH marsh m AVE. STREAM DEPTH 2.5 ft. VELOCITY 0 ms STREAM km _____
STREAM SHADING: Open Partly Open Shaded STREAM TYPE: Coldwater Warmwater
WATER TEMP. 74°F AIR TEMP. 65°F WEATHER: Sunny-Partly Cloudy-Cloudy-Rainy DAM u/s: Yes No _____ km
CHANNELIZED: Yes No CHANNEL EROSION: None — Slight — Moderate — Severe HIGH WATER MARK 6 in.
SECCHI DISC TRANS: 3 ft TURBIDITY: Clear—Slightly Turbid—Turbid—Opaque WATER COLOR light brown
WATER ODORS: Normal Sewage Petroleum Chemical Other _____
SURFACE OILS: None Slick Sheen Globbs Flecks

SEDIMENT ODORS: Normal Sewage Petroleum Chemical Anaerobic Other _____
SEDIMENT OILS: Absent Slight Moderate Profuse
DEPOSITS: Sludge Sawdust Paperfiber Sand Relict Shells Other _____
ARE THE UNDERSIDES OF STONES WHICH ARE NOT DEEPLY IMBEDDED IN SUBSTRATE BLACK? YES NO

SUBSTRATE TYPE	FLOW VELOCITY m/sec	CHARACTERISTICS OR SIZE	PERCENT IN SAMPLING AREA	SUBSTRATE TYPE	CHARACTERISTICS OR SIZE	PERCENT IN SAMPLING AREA
BOULDERS*	>1.2 (>3 fps)	256 mm (10") dia.		CLAY	Slick texture	
RUBBLE*	>0.6 (>2 fps)	64-256 mm (2.1-10") dia.		MARL	Grey, shell fragments	
GRAVEL*	>0.3 (>1 fps)	2-64 mm (0.1-2.5") dia.		DETRITUS	Sticks, wood, coarse plant materials	70
SAND	>0.2 (>0.7 fps)	0.06-2.00 mm dia. Gritty texture		FIBROUS PEAT	Partially decomposed plant material	
SILT	>0.12 (>0.4 fps)	0.004-0.006 mm dia.		PULPY PEAT	Finely divided plant material, parts indistinguishable	10
MUCK-MUD	>0.12 (>0.4 fps)	black, very fine organic	20	LOGS & STICKS		
*IMBEDDEDNESS: 0 = NONE 1 = 1/3 OR LESS 2 = 2/3 OR MORE						

BIOLOGY:

PHYTOPLANKTON	0	1	2	3	4	SLIMES	<u>0</u>	1	2	3	4
PERIPHYTON	0	1	<u>2</u>	3	4	ZOOPLANKTON	0	1	2	<u>3</u>	4
FILAMENTOUS ALGAE	0	1	<u>2</u>	3	4	MACROINVERTEBRATES	0	1	<u>2</u>	3	4
MACROPHYTES	0	1	<u>2</u>	3	4	FISH	0	1	2	3	4

000038 none seen

FISH
 GAME FISH
 ROUGH FISH
 FORAGE FISH

MACROPHYTES		PERIPHYTON	FILAMENTOUS ALGAE
<u>Typha</u>	<u>Elodea</u>	periphyton or algae coats everything in this area	
<u>Scirpus</u>	<u>Potamogeton</u>		
<u>Lemna minor</u>			

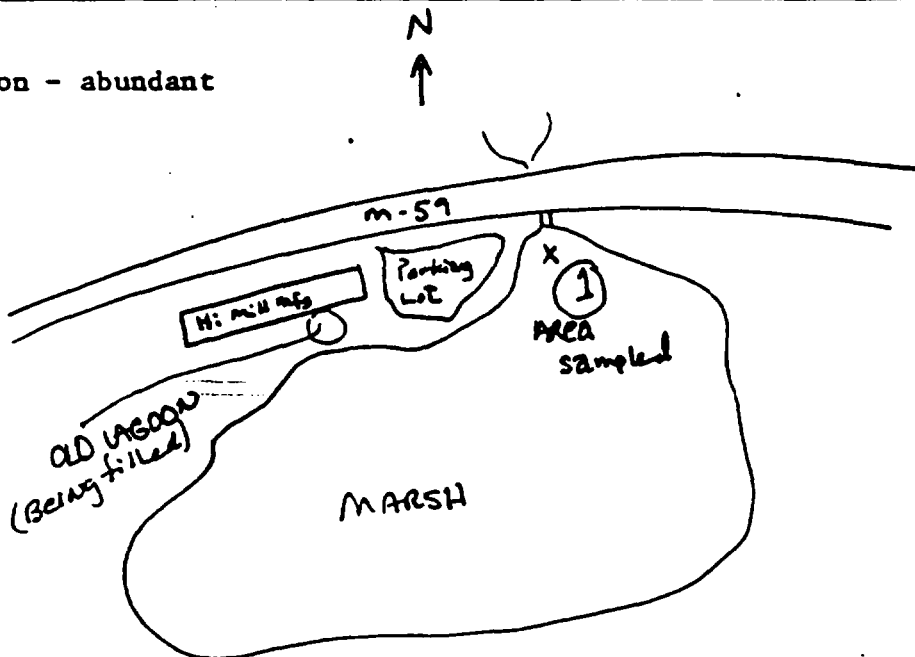
STREAMBANK VEGETATION: GRASSES BRUSH HERBACEOUS CONIFERS DECIDUOUS BARREN OTHER _____

MACROBENTHOS QUALITATIVE SAMPLE CHECK LIST (INDICATE DOMINANT GROUPS)

SPONGES	DRAGONFLIES	RATTAILED MAGGOTS
HYDRA	DAMSELFLIES	MIDGES C-A
FLATWORMS	TRUE BUGS	STONEFLIES
ROUNDWORMS	BETTER	MAYFLIES
LEECHES	AQUATIC CATERPILLARS	-BURROWERS
WATER MITES	ALDERFLIES	-SWIMMERS
SOWBUGS	HELLGRAMITES	-CLINGERS, SPRAWLERS
UDS	CRANEFLIES	CADDISFLIES
CRAYFISH	NO-SEE-UMS	-FREE LIVING
SNAILS-LIMPETS	BLACKFLIES	-PURSE CASE MAKERS
CLAMS	DEERFLIES	-TUBE CASE MAKERS
AQUATIC EARTHWORMS	MOSQUITOES	-SADDLECASE MAKERS
	SHRIMP	-NET SPINNERS OR RETREATMAKERS

NOTES, ETC.

Zooplankton - abundant



000039

MICHIGAN DEPARTMENT OF NATURAL RESOURCES
WATER QUALITY DIVISION

BIOLOGY SECTION
STREAM PROBLEM ASSESSMENT

Station Number 2 Investigator(s) Kenaga, Wuycheck
Date 4 / 26 / 84 TIME 12:30 PHOTOGRAPH NUMBER _____
BODY OF WATER marsh SE of Hi-Mill Mfg. LOCATION SE of Hi-Mill near outlet from old lagoons
COUNTY Oakland T3N R7E S Highland TWP _____
REASON FOR SURVEY Hi-Mill Mfg.

VICINITY LAND USE: Mostly Forest Mostly Urban Mostly Agriculture Other _____
AVE. STREAM WIDTH marsh m AVE. STREAM DEPTH 2.5 ft VELOCITY 0 ms STREAM km _____
STREAM SHADING: Open Partly Open Shaded STREAM TYPE: Coldwater Warmwater
WATER TEMP. 74°F AIR TEMP. 65°F WEATHER: Sunny-Partly Cloudy-Cloudy-Rainy DAM u/s: Yes No km _____
CHANNELIZED: Yes No CHANNEL EROSION: None — Slight — Moderate — Severe HIGH WATER MARK 6 ft
SECCHI DISC TRANS: 3 ft. TURBIDITY: Clear-Slightly Turbid-Turbid-Opaque WATER COLOR _____
WATER ODORS: Normal Sewage Petroleum Chemical Other _____
SURFACE OILS: None Slick Sheen Globbs Flecks

SEDIMENT ODORS: Normal Sewage Petroleum Chemical Anaerobic Other _____
SEDIMENT OILS: Absent Slight Moderate Profuse
DEPOSITS: Sludge Sawdust Paperfiber Sand Relict Shells Other _____
ARE THE UNDERSIDES OF STONES WHICH ARE NOT DEEPLY IMBEDDED IN SUBSTRATE BLACK? YES NO

SUBSTRATE TYPE	FLOW VELOCITY m/sec	CHARACTERISTICS OR SIZE	PERCENT IN SAMPLING AREA	SUBSTRATE TYPE	CHARACTERISTICS OR SIZE	PERCENT IN SAMPLING AREA
BOULDERS*	>1.2 (>3 fps)	256 mm (10") dia.		CLAY	Slick texture	
RUBBLE*	>0.6 (>2 fps)	64-256 mm (2.1-10") dia.		MARL	Grey, shell fragments	
GRAVEL*	>0.3 (>1 fps)	2-64 mm (0.1-2.5") dia.		DETRITUS	Sticks, wood, coarse plant materials	70
SAND	>0.2 (>0.7 fps)	0.06-2.00 mm dia. Gritty texture		FIBROUS PEAT	Partially decomposed plant material	
SILT	>0.12 (>0.4 fps)	0.004-0.006 mm dia.		PULPY PEAT	Finely divided plant material, parts indistinguishable	10
MUCK-MUD	>0.12 (>0.4 fps)	black, very fine organic	20	LOGS & STICKS		
* IMBEDDEDNESS: 0 = NONE 1 = 1/3 OR LESS 2 = 2/3 OR MORE						

BIOQA:

PHYTOPLANKTON	0	1	2	3	4	SLIMES	0	1	2	3	4
PERIPHYTON	0	1	2	3	4	ZOOPLANKTON	0	1	2	3	4
FILAMENTOUS ALGAE	0	1	2	3	4	MACROINVERTEBRATES	0	1	2	3	4
MACROPHYTES	0	1	2	3	4	FISH	0	1	2	3	4

000040

none seen

2 - Moderate

3 - Abundant

4 - Profuse

FISH

GAME FISH

ROUGH FISH

FORAGE FISH

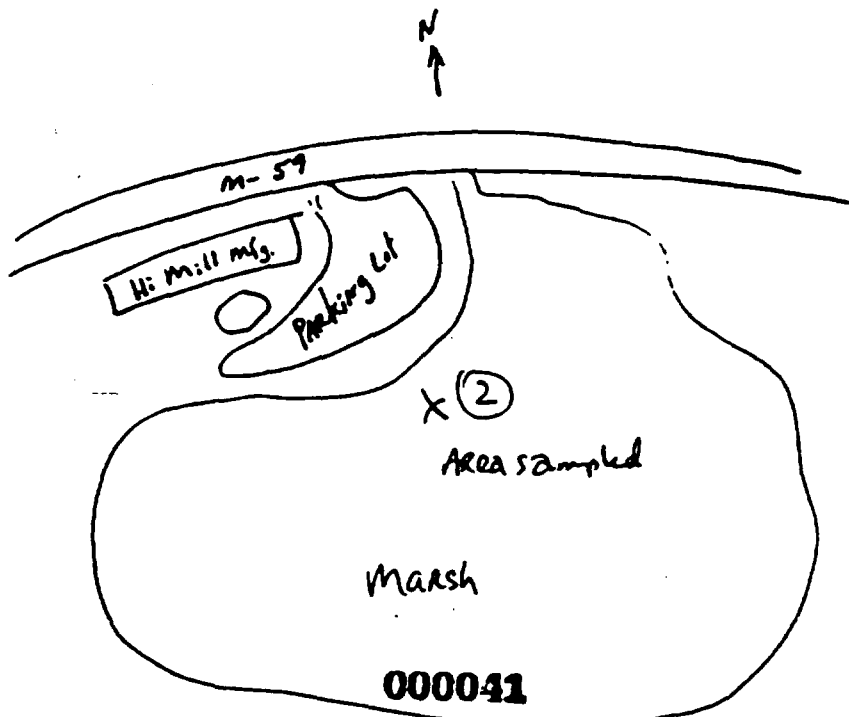
ATIC PLANTS		PERIPHYTON	FILAMENTOUS ALGAE
MACROPHYTES	<u>Typha</u>	<u>Elodea</u>	Periphyton and/or filamentous algae covered everything in this area.
	<u>Scirpus</u>	<u>Potamogeton</u>	
	<u>Lemma minor</u>		

STREAMBANK VEGETATION:	GRASSES	BRUSH	HERBACEOUS	CONIFERS	DECIDUOUS	BARREN	OTHER
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MACROBENTHOS QUALITATIVE SAMPLE CHECK LIST (INDICATE DOMINANT GROUPS)

SPONGES	DRAGONFLIES	RATTAILED MAGGOTS
HYDRA	DAMSELFLIES	MIDGES C-A
FLATWORMS	TRUE BUGS	STONEFLIES
ROUNDWORMS	BEETLES	MAYFLIES
LEECHES	AQUATIC CATERPILLARS	-BURROWERS
WATER MITES	ALDERFLIES	-SWIMMERS
SOWBUGS	HELLGRAMITES	-CLINGERS, SPRAWLERS
IDS	CRANEFLIES	CADDISFLIES
CRAYFISH	NO-SEE-UMS	-FREE LIVING
SNAILS-LIMPETS	BLACKFLIES	-PURSE CASE MAKERS
CLAMS	DEERFLIES	-TUBE CASE MAKERS
AQUATIC EARTHWORMS	MOSQUITOES	-SADDLECASE MAKERS
	SNIFEFLIES	-NET SPINNERS OR RETREATMAKERS

NOTES, ETC. Zooplankton - Abundant in water column



MICHIGAN DEPARTMENT OF NATURAL RES. 25
WATER QUALITY DIVISION

BIOLOGY SECTION
STREAM PROBLEM ASSESSMENT

Station Number 3 Investigator(s) Kenaga, Wuycheck
Date 4 / 26 / 84 TIME 1:00 PHOTOGRAPH NUMBER _____
Roof and Parking new Hi-Mill Mfg.
BODY OF WATER 100' off to marsh SE of LOCATION pipe at east edge of parking lot
COUNTY Oakland T 3N R 7E S 23 TWP Highland
REASON FOR SURVEY Hi-Mill Mfg. Co.

VICINITY LAND USE: Mostly Forest Mostly Urban Mostly Agriculture Other _____
AVE. STREAM WIDTH 6 in AVE. STREAM DEPTH 1 in VELOCITY <0.4 fps STREAM km _____
STREAM SHADING: Open Partly Open Shaded STREAM TYPE: Coldwater Warmwater
WATER TEMP. _____ °C AIR TEMP. 65 °F WEATHER: Sunny-Partly Cloudy Cloudy Rainy DAM u/s: Yes No km _____
CHANNELIZED: Yes No CHANNEL EROSION: None Slight Moderate Severe HIGH WATER MARK 6 in
SECCHI DISC TRANS: _____ m TURBIDITY: Clear Slightly Turbid Turbid Opaque WATER COLOR _____
WATER ODORS: Normal Sewage Petroleum Chemical Other _____
SURFACE OILS: None Slick Sheen Globbs Flecks
SEDIMENT ODORS: Normal Sewage Petroleum Chemical Anaerobic Other _____
SEDIMENT OILS: Absent Slight Moderate Profuse
DEPOSITS: Sludge Sawdust Paperfiber Sand Relict Shells Other _____
ARE THE UNDERSIDES OF STONES WHICH ARE NOT DEEPLY IMBEDDED IN SUBSTRATE BLACK? YES NO

SUBSTRATE TYPE	FLOW VELOCITY m/sec	CHARACTERISTICS OR SIZE	PERCENT IN SAMPLING AREA	SUBSTRATE TYPE	CHARACTERISTICS OR SIZE	PERCENT IN SAMPLING AREA
BOULDERS*	>1.2 (>3 fps)	256 mm (10") dia.		CLAY	Slick texture	
RUBBLE*	>0.6 (>2 fps)	64-256 mm (2.1-10") dia.		MARL	Grey, shell fragments	
GRAVEL*	>0.3 (>1 fps)	2-64 mm (0.1-2.5") dia.		DETRITUS	Sticks, wood, coarse plant materials	70
SAND	>0.2 (>0.7 fps)	0.06-2.00 mm dia. Gritty texture		FIBROUS PEAT	Partially decomposed plant material	
SILT	>0.12 (>0.4 fps)	0.004-0.006 mm dia.		PULPY PEAT	Finely divided plant material, parts indistinguishable	10
MUCK-MUD	>0.12 (>0.4 fps)	black, very fine organic	10	LOGS & STICKS		
*IMBEDDEDNESS: 0 = NONE 1 = 1/3 OR LESS 2 = 2/3 OR MORE						

BIOA:

PHYTOPLANKTON	<u>0</u>	1	2	3	4	SLIMES	<u>0</u>	1	2	3	4
PERIPHYTON	0	1	<u>2</u>	3	4	ZOOPLANKTON	<u>0</u>	1	2	3	4
FILAMENTOUS ALGAE	0	1	<u>2</u>	3	4	MACROINVERTEBRATES	<u>0</u>	1	2	3	4
MACROPHYTES	<u>0</u>	1	2	3	4	FISH	<u>0</u>	1	2	3	4

0 - Absent

1 - Sparse

2 - Moderate

3 - Abundant

4 - Profuse

000042

FISH

GAME FISH

ROUGH FISH

FORAGE FISH - one dead mud minnow near parking lot runoff site

AQUATIC PLANTS

PERIPHYTON

FILAMENTOUS ALGAE

MACROPHYTES

STREAMBANK
VEGETATION:

GRASSES

BRUSH

HERBACEOUS

CONIFERS

DECIDUOUS

BARREN

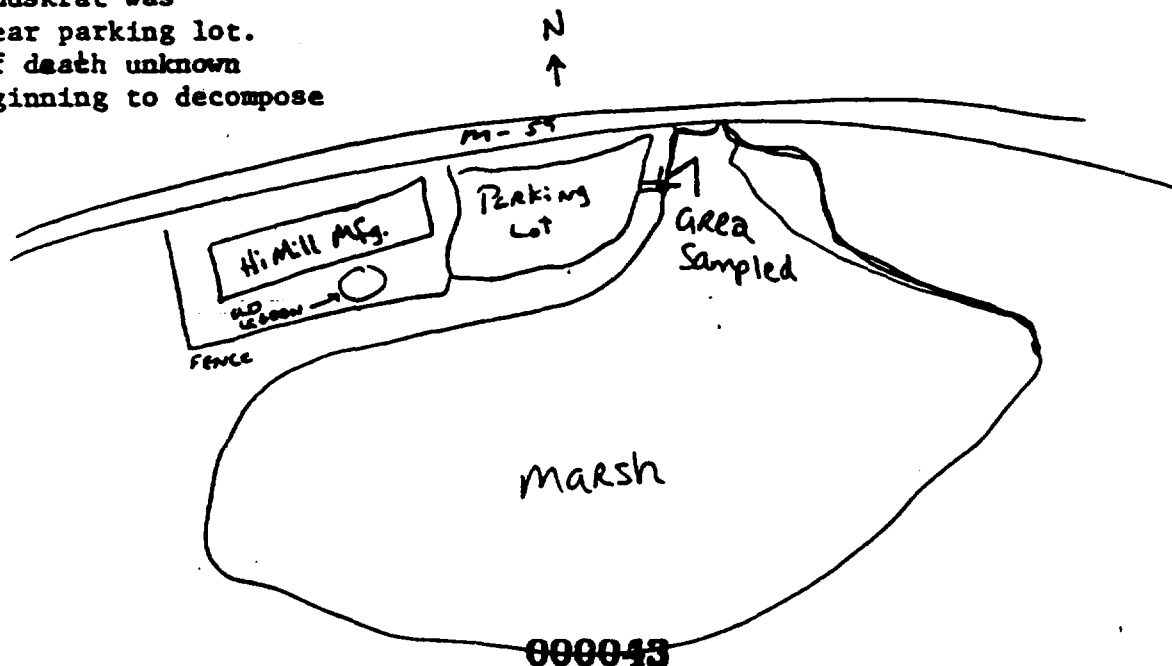
OTHER

MACROBENTHOS QUALITATIVE SAMPLE CHECK LIST (INDICATE DOMINANT GROUPS)

SPONGES	DRAGONFLIES	RATTAILED MAGGOTS
HYDRA	DAMSELFLIES	MIDGES
FLATWORMS	TRUE BUGS	STONEFLIES
ROUNDWORMS	BEETLES	MAYFLIES
LEECHES	AQUATIC CATERPILLARS	-BURROWERS
WATER MITES	ALDERFLIES	-SWIMMERS
SOWBUGS	HELLGRAMITES	-CLINGERS, SPRAWLERS
SCUDS	CRANEFLIES	CADDISFLIES
RAYFISH	NO-SEE-UMS	-FREE LIVING
SNAILS-LIMPETS	BLACKFLIES	-PURSE CASE MAKERS
CLAMS	DEERFLIES	-TUBE CASE MAKERS
AQUATIC EARTHWORMS	MOSQUITOES	-SADDLECASE MAKERS
	SNIPEFLIES	-NET SPINNERS OR RETREATMAKERS

NOTES, ETC. No macroinvertebrates in small trickel

A dead muskrat was
noted near parking lot.
Cause of death unknown
body beginning to decompose



FISH

GAME FISH

ROUGH FISH

FORAGE FISH

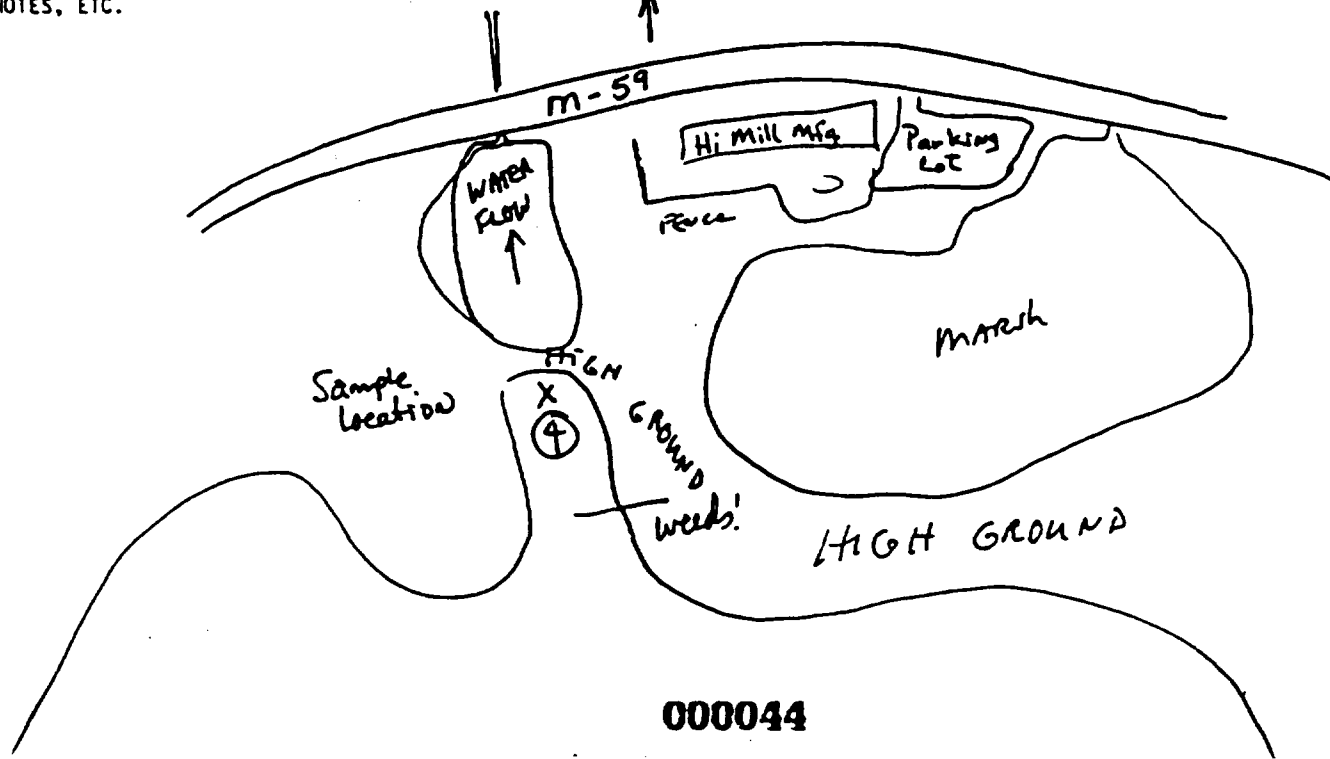
- minnows noted in shallow areas

AQUATIC PLANTS		PERIPHYTON	FILAMENTOUS ALGAE		
MACROPHYTES	<u>Scirpus</u>	<u>Potamogeton</u>			
	<u>Typha</u>	<u>Nuphar</u>			
	<u>Chaga</u>	<u>Nymphaea</u>			
STREAMBANK VEGETATION:					
	<u>GRASSES</u>	<u>BRUSH</u>	<u>HERBACEOUS</u>	<u>CONIFERS</u>	<u>DECIDUOUS</u>
					<u>BARREN</u>
					<u>OTHER</u>

MACROBENTHOS QUALITATIVE SAMPLE CHECK LIST (INDICATE DOMINANT GROUPS)

Sponges	Dragonflies	Rat-tailed Maggots
Hydra	Damselflies	Midges
Flatworms	True Bugs	Stoneflies
Roundworms	Beetles	Mayflies
Leeches	Aquatic Catterpillars	-Burrowers
Water Mites	Alderflies	-Swimmers
Sowbugs	Hellgramites	-Clingers, Sprawlers
Scuds	Craneflies	Caddisflies
Rayfish	No-see-ums	-Free Living
Snails-Limpets	Blackflies	-Purse Case Makers
Clams	Deerflies	-Tube Case Makers
Aquatic Earthworms	Mosquitoes	-Saddlecase Makers
	Snipeflies	-Net Spinners or Retreatmakers

NOTES, ETC.



000044

MICHIGAN DEPARTMENT OF NATURAL RESOURCES
WATER QUALITY DIVISION

BIOLOGY SECTION
STREAM PROBLEM ASSESSMENT

Station Number 4 Investigator(s) Kenaga, Wuycheck
Date 4 / 26 / 84 TIME 2:00 PHOTOGRAPH NUMBER _____
BODY OF WATER Waterburg Lake LOCATION at outlet
COUNTY Oakland T3N R7E S 23 TWP HIGHLAND
REASON FOR SURVEY H1-Mill Mfg. Co.

VICINITY LAND USE: Mostly Forest Mostly Urban Mostly Agriculture Other Park
AVE. STREAM WIDTH Lake AVE. STREAM DEPTH 5 ft. VELOCITY — ms STREAM km
STREAM SHADING: Open Partly Open Shaded STREAM TYPE: Coldwater Warmwater
WATER TEMP. — °C AIR TEMP. 65° WEATHER: Sunny-Partly Cloudy-Cloudy-Rainy DAM u/s: Yes No km
CHANNELIZED: Yes No CHANNEL EROSION: None — Slight — Moderate — Severe HIGH WATER MARK 2 ft
SECCHI DISC TRANS: 5 ft. TURBIDITY: Clear — Slightly Turbid — Turbid — Opaque WATER COLOR clear
WATER ODORS: Normal Sewage Petroleum Chemical Other
SURFACE OILS: None Slick Sheen Globbs Flecks

SEDIMENT ODORS: Normal Sewage Petroleum Chemical Anaerobic Other
SEDIMENT OILS: Absent Slight Moderate Profuse
DEPOSITS: Sludge Sawdust Paperfiber Sand Relict Shells Other
ARE THE UNDERSIDES OF STONES WHICH ARE NOT DEEPLY IMBEDDED IN SUBSTRATE BLACK? YES NO

SUBSTRATE TYPE	FLOW VELOCITY m/sec	CHARACTERISTICS OR SIZE	PERCENT IN SAMPLING AREA	SUBSTRATE TYPE	CHARACTERISTICS OR SIZE	PERCENT IN SAMPLING AREA
BOULDERS*	>1.2 (>3 fps)	256 mm (10") dia.		CLAY	Slick texture	
RUBBLE*	>0.6 (>2 fps)	64-256 mm (2.1-10") dia.		MARL	Grey, shell fragments	
GRAVEL*	>0.3 (>1 fps)	2-64 mm (0.1-2.5") dia.		DETRITUS	Sticks, wood, coarse plant materials	00
SAND	>0.2 (>0.7 fps)	0.06-2.00 mm dia. Gritty texture		FIBROUS PEAT	Partially decomposed plant material	
SILT	>0.12 (>0.4 fps)	0.004-0.006 mm dia.		PULPY PEAT	Finely divided plant material, parts indistinguishable	20
MUCK-MUD	>0.12 (>0.4 fps)	black, very fine organic	20	LOGS & STICKS		
*IMBEDDEDNESS: 0 = NONE 1 = 1/3 OR LESS 2 = 2/3 OR MORE						

BIOTA:

PHYTOPLANKTON	0	1	2	3	4	SLIMES	0	1	2	3	4
PERIPHYTON	0	1	2	3	4	ZOOPLANKTON	0	1	2	3	4
FILAMENTOUS ALGAE	0	1	2	3	4	MACROINVERTEBRATES	0	1	2	3	4
MACROPHYTES	0	1	2	3	4	FISH	0	1	2	3	4

0 - Absent

1 - Sparse

2 - Moderate

000045

3 - Abundant

4 - Profuse

APRIL - OCTOBER 1987

NUMATICS, INC. DISCHARGE PERMIT DATA

000046

STATE OF MICHIGAN
WATER RESOURCES COMMISSION

PERMIT

Name of Applicant NUMATICS, INCORPORATED
Address of Applicant 1415 N. Milford Road, Highland, Michigan

Numatics, Incorporated, Highland, Michigan, has filed with the Water Resources Commission, an application dated February 20, 1974, for a permit to discharge treated wastewaters to the waters of the state. The application states that Numatics Incorporated, Highland, Michigan proposes to dispose of approximately twelve thousand two hundred (12,200) gallons per day of cooling water; two thousand (2,000) gallons per day of rinse water and eight hundred (800) gallons per day of sanitary sewage for a total of fifteen thousand (15,000) gallons per day from an existing manufacturing operation into the ground at its facilities located at 2000 Highland Road East, Highland, Michigan.

The Commission, having given due consideration to the application and investigations by its staff hereby authorizes the applicant, Numatics, Incorporated, to discharge treated wastewaters to the groundwaters of the state in accordance with the conditions specified herein.

I. General Conditions:

A. All discharges shall be consistent with the terms and conditions of this permit. Any changes in production capacity, process modifications or facility expansion which result in new or increased discharges of wastes must be authorized by a new permit or by modifications of this permit.

B. After notice and opportunity for a hearing, this Permit may be modified, suspended, or revoked in whole or in part for cause, including, but not limited to:

1. Violation of any terms or conditions of this Permit, obtaining a permit by misrepresentation or failure to disclose fully all relevant facts; or
2. A change in conditions or the existence of a condition which requires either a temporary or permanent reduction or elimination of the authorized discharge.

C. The permittee shall at all times maintain in good working order and operate, as efficiently as possible, all treatment or control facilities necessary to achieve compliance with the terms and conditions of this Permit.

D. This Permit is permissive and its issuance does not convey any property rights in either real or personal property, or any exclusive privileges, nor does it authorize any injury to private property or any invasion of personal rights, nor any infringement of Federal, State or local laws or regulations, nor does it obviate the necessity of obtaining such permits or approvals from other units of government as may be

required by law. This permit is issued with the understanding that it does not prevent the State of Michigan from subsequent establishment of further requirements for treatment or control at any time.

E. The restrictions and conditions of this Permit shall apply to any person or legal entity which now or shall hereafter own or operate the facilities for which this Permit is issued. The permittee shall immediately notify the Water Resources Commission of such change in ownership or principal operator status for this facility.

II. Special Conditions:

A. Rinse waters resulting from the manufacturing operations stated in the application to be two thousand (2,000) gallons per day shall be treated or controlled by facilities in such a manner that they shall:

1. Contain not more than five tenths (0.5) of a milligram per liter of filtrable nickel measured as the Ni ion.
2. Contain not more than five hundredths (0.05) of a milligram per liter of total filtrable chromium measured as the Cr ion.
3. Contain not more than ten (10) milligrams per liter of nitrate+ nitrite nitrogen, expressed as nitrogen (N).
4. Have a pH of not less than 8.5 nor more than 10.5

B. Cooling water resulting from the manufacturing operation stated in the application to be twelve thousand two hundred (12,200) gallons per day, shall be disposed of into the ground in such manner and by means of such facilities and at such location that they shall not injuriously affect public health or welfare, or commercial, industrial, domestic, agricultural, recreational or other uses of the underground waters or surface waters of the state.

C. Sanitary sewage shall be disposed of into the ground by approved subsurface percolation methods.

D. All spent concentrated acid-alkali rinse waters shall be removed from the premises by a liquid industrial waste hauler licensed under the provisions of Act 136, Public Acts of 1969.

E. The Permittee shall provide approved facilities for containment of any accidental losses of concentrated processing solutions, acids and alkalis or other toxic or hazardous substances in accordance with the Water Resources Commission Rules, Part 5.

F. Facilities necessary for compliance with the restrictions and special conditions set forth herein shall be constructed in accordance with plans submitted, in triplicate, to and approved by the Chief Engineer of the Commission.

G. The Chief Engineer of the Commission shall be notified by letter of the proposed schedule for construction of the waste control facilities at least two (2) weeks prior to the commencing of construction.

H. There shall be no bypassing of the waste control facilities at any time where such bypass would allow the entry of untreated or inadequately treated wastes to any waters of the state. In the event the permittee is unable to comply with any of the conditions of this permit, due to breakdown of equipment, accidents, or other causes, the permittee shall notify the Chief Engineer of the Commission immediately (by telephone and) in writing. The written notification shall include pertinent information explaining the reasons for the non-compliance and shall indicate what steps are being taken to correct the problem and to prevent the problem from recurring.

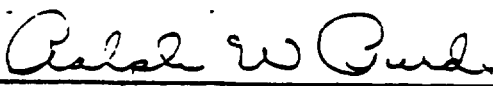
I. All wastewaters from this facility shall be connected to any sanitary sewer system which may be provided by any governmental unit, within sixty (60) days from the date when said sewer becomes available. At that time any restrictions and conditions imposed by said governmental unit shall supersede the restrictions and conditions of this Permit and this Permit shall then be terminated.

J. It is further made a condition of this permit that the applicant give notice to public utilities in accordance with Act No. 53 of the Public Acts of 1974, being sections 460.701 to 460.718 of the Michigan Compiled Laws, and comply with each of the requirements of that Act.

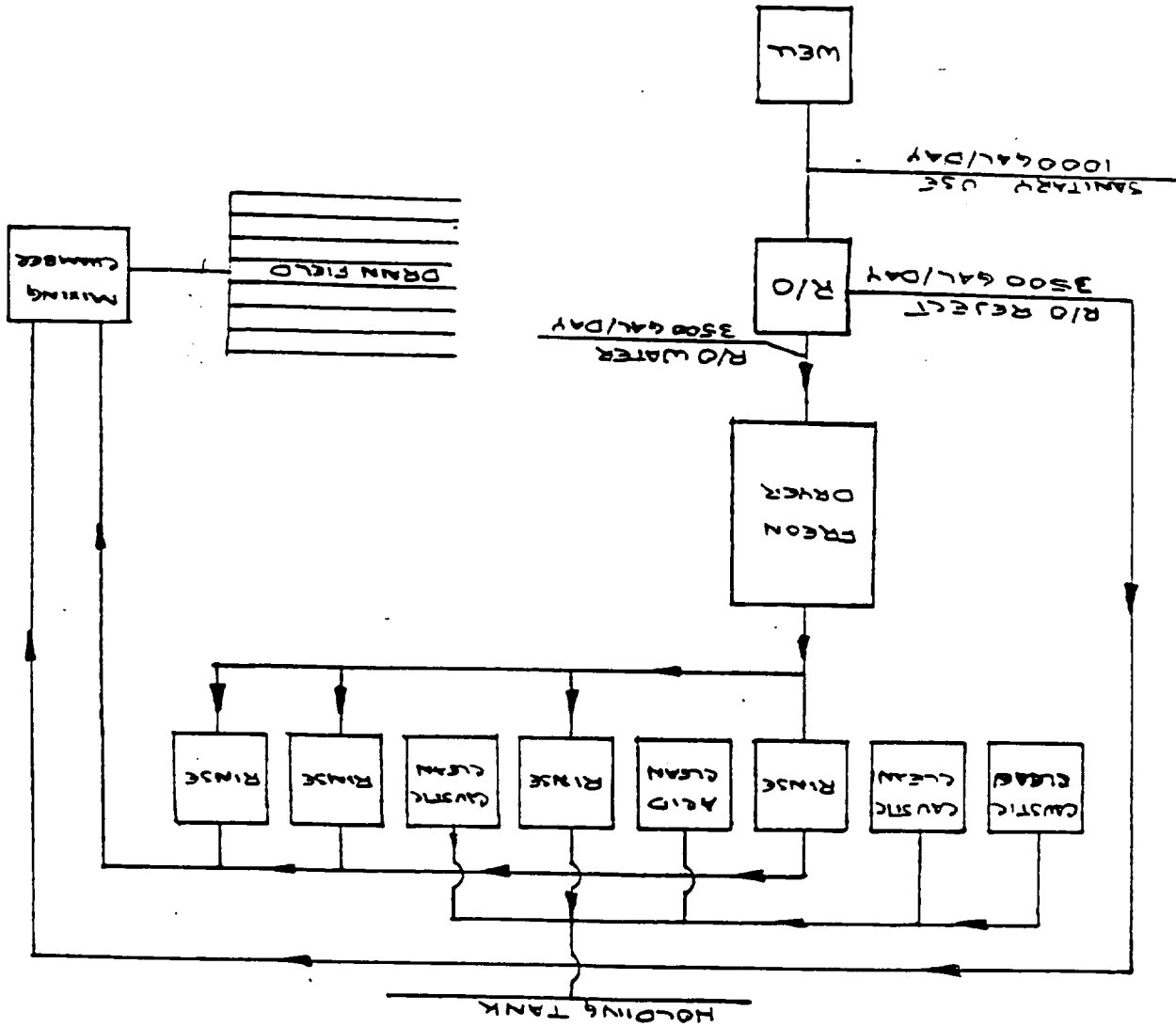
K. In the event that the provisions of this permit are not utilized within a two-year period, then the Permit shall become void and of no further force or effect, requiring the resubmission of a statement at such time as the development is again proposed.

L. The Permittee shall provide flow measuring devices and make or cause to be made, sampling and analyses of its wastewater discharges at the frequency and for the parameters indicated on the attached monitoring conditions and reports thereon shall be submitted to the Chief Engineer of the Commission at the end of each calendar month.

This Permit issued this 1st day of November, 1974, by the Commission in accordance with Act 245, Public Acts of 1929, as amended, shall be final in the absence of a request for a hearing filed within 15 days after receipt hereof.



Ralph W. Purdy
Executive Secretary



PROPERTY LINE

WATER SUPPLY WELL

HIGHLAND PRECISION

SEPTIC TANKS & DRAIN FIELD

M-S-9

PROPERTY LINE

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MW-3
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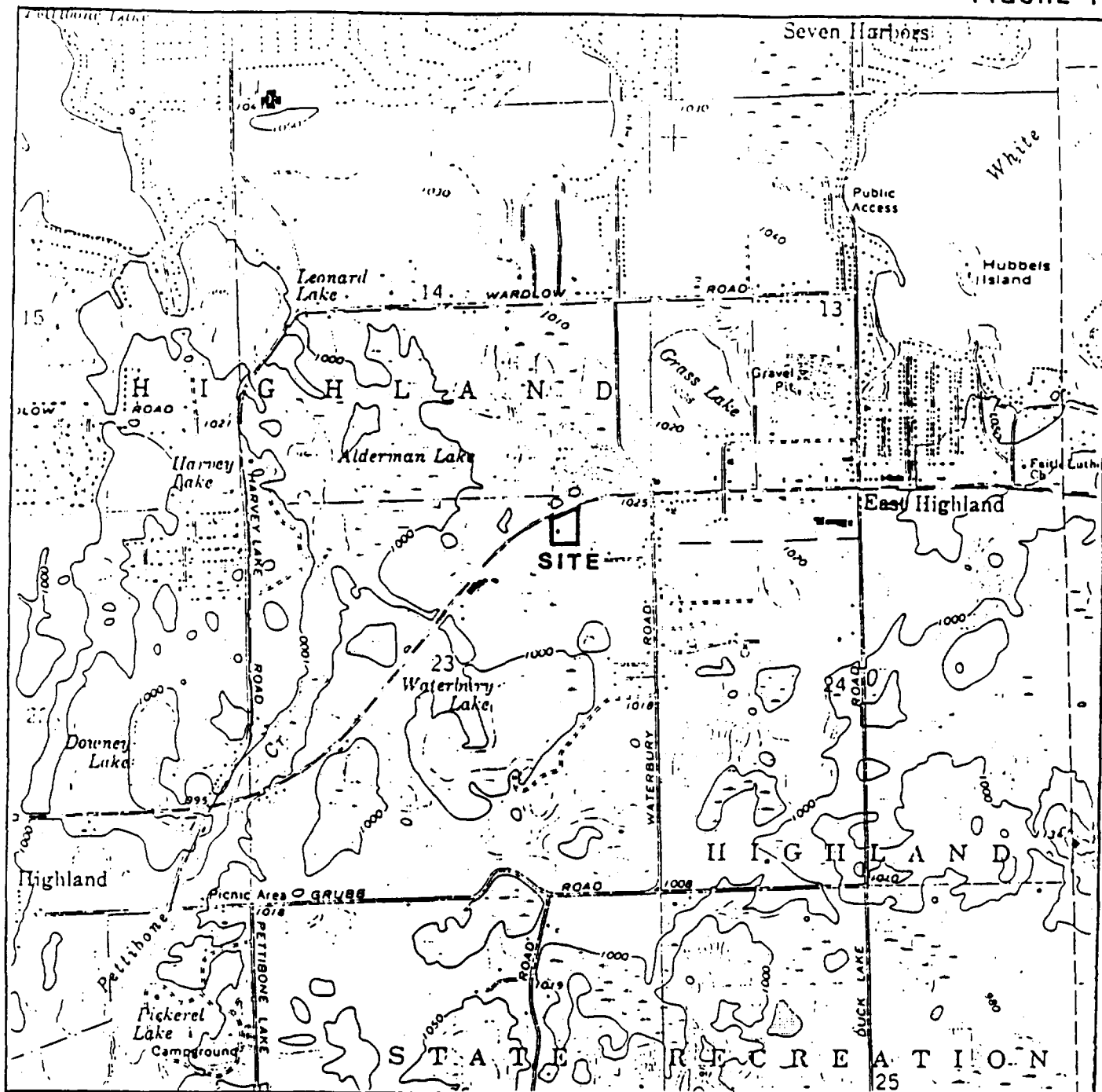
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ROCK CONSULTING SERVICES, INC.

FIGURE 1



SITE LOCATION MAP

NUMATICS - HIGHLAND PRECISION PLANT

T.3N., R.7E., SECTION 23

HIGHLAND TWP., OAKLAND CO., MICHIGAN

NORTH

0 feet 2000

000052

Adapted from USGS topographic quadrangle - Highland 7.5' 1983

☐ KECK consulting services, inc.

HISTORY AND PERMIT DEVELOPMENT BACKGROUND:

In 1974, Numatics, Incorporated purchased the existing plant and property owned by the Highland Precision Company to manufacture small stainless steel parts. It was issued its first discharge permit on November 1, 1974 that allowed for the disposal of approximately 12,200 gpd of cooling water, 2,000 gpd of rinse water and 800 gpd of sanitary sewage. This permit had no expiration date specified.

An application for the renewal was received on May 31, 1985. Numerous supplements have been added to the original application including a hydrogeological study. An amended application form was received on September 23, 1987, and on this it was clarified that reverse osmosis system will replace the present ion exchange water softener. This would allow the reject water to be discharged directly to the absorption bed for disposal.

CURRENT PERMIT: (See Attached Sheets)

DRAFT PERMIT: (See Attached Sheets)

REGISTER OF INTERESTED PERSONS:

Any person interested in a particular application or group of groundwater permit applications, may request to be on mailing lists of the Waste Management Permits Section to receive public notices and/or fact sheets.

PUBLIC HEARING:

If submitted comments indicate a significant public interest in the application, the Michigan Water Resources Commission, at its discretion, may hold a public hearing on the application. Any person may request the Michigan Water Resources Commission to hold a public hearing on an application. The request should include specific reasons, indicating which portions of the application or draft permit are of concern.

If a Public Hearing is held, public notice of the hearing will be circulated at least thirty (30) days in advance of hearings. The hearing will normally be held in the vicinity of the discharge.

For further information concerning the project, contact the Department of Natural Resources, Waste Management Permits Section, P. O. Box 30028, Lansing, Michigan, 48909, telephone (517) 373-8148.

BACKGROUND GROUNDWATER QUALITY:

Sample taken 5-1-87 from observation well OW-2, located 150 feet north and lateral to the disposal field.

<u>Parameter</u>	<u>Concentration</u>
Calcium	58 mg/l
Magnesium	14 mg/l
Sodium	1.9 mg/l
Chloride	7.2 mg/l
Bicarbonate Alkalinity	160 mg/l
Sulfate	16 mg/l
Ammonia-Nitrogen	0.1 mg/l
Nitrate-Nitrogen	.18 mg/l
Total Phosphorus	.37 mg/l
Hexavalent Chromium	.01 mg/l
Cadmium, dissolved	.02 mg/l
Copper, Dissolved	.02 mg/l
Iron, dissolved	.06 mg/l
Lead, dissolved	.02 mg/l
Nickel, dissolved	.05 mg/l
Zinc, dissolved	.02 mg/l
pH	7.7

MAPS OF DISCHARGE LOCATION: (See Attached Sheets)

EXISTING EFFLUENT QUALITY:

Sample taken on August 16, 1987, prior to discharge to disposal field. The proposed effluent quality is not expected to change significantly.

<u>Parameter</u>	<u>Concentration</u>
Specific Conductance	675 umhos/cm
Chloride	27 mg/l
Total Hardness, as CaCO ₃	12 mg/l
Nitrate-Nitrogen	.10 mg/l
Nitrite-Nitrogen	.01 mg/l
Ammonia-Nitrogen	2.1 mg/l
Nickel	.04 mg/l
Chromium	.02 mg/l
Dissolved Aluminum	.1 mg/l
Dissolved Cadmium	.01 mg/l
Dissolved Zinc	.005 mg/l
Dissolved Lead	.05 mg/l
Dissolved Iron	.06 mg/l

The remaining 7,000 gallons currently goes through a conventional ion exchange water softener. The backwash from the softener is discharged to a holding tank and hauled away on a daily basis.

In order to reduce the hauling costs the company is proposing to install a reverse osmosis (R-O) system in place of the water softener. Half of the 7,000 gallons would be reject water and would be drained to a mixing chamber where it would ultimately be mixed with rinse water and discharged to the ground. The purified half would be used as noncontact cooling water for the freon dryer and then as rinse water for their parts cleaning operation. The cleaning operation consists of three caustic clean tanks, one acid clean tank, and four rinse water tanks. The contents of the caustic and acid tanks and the one rinse tank that follows the acid clean tank are hauled away by licensed hazardous waste hauler. The three remaining rinse tanks discharge to the mixing chamber where they would combine with the reject water from the R-O system.

Final discharge for the 7,000 gallons per day (3,500 gpd of process water and 3,500 gpd of reverse osmosis reject water) would be to the existing tile field.

SUMMARY OF HYDROGEOLOGIC CONDITIONS:

Regional Geology

Regionally the site is located in an area mapped as coarse textured end moraine, characterized by unsorted and unstratified soils. These soils range from sandy clay loams to loamy sands and contain varying amounts of gravel and cobbles. Drift thickness in the area ranges from 50-500 feet thick and averages 200-300 feet thick, overlying the Mississippian-aged, Coldwater Shale bedrock formation. The Coldwater is largely a blue-grey shale with occasional limestone and dolomite horizons near its base. This formation is not an aquifer system so virtually all private water wells in the area are set in drift aquifers.

Well logs in the vicinity of the site range from 40-90 feet below the surface. The clay observed in these logs occurs at varying depths and could not be established to be continuous. The nearest upgradient well is located approximately 1/4 mile east of the site, along Waterbury Road. The nearest downgradient well is the facility water supply well, located 100 feet southwest of the disposal site.

Site Specific Geology

On-site soils are classified as Tedrow loamy sands with 0-3% slopes. Elevations across the site are fairly level, approximately 1015 USGS throughout. Four soil boring/observation wells installed 25-50 feet deep on-site reveal sands with some gravel, with discontinuous clay lenses occurring at varying elevations. The site is located in a recharge area, with depth to groundwater approximately 12 feet and flow direction to the southwest with a gradient of .004.

August 10, 1987

Mr. Matt Murphy
Numatics, Inc.
11450 N. Milford Road
Highland, Michigan 48031

Dear Mr. Murphy:

Subject: Numatics Facility located at 2000 Highland Road

I am enclosing a copy of the memo from Dan O'Neil (of our Land Application Unit) to myself, concerning the levels of Chrome found in the soils around Numatic's drainfield discharge area.

Mr. O'Neil is concerned that soil sampling inconsistencies may have skewed the data, making the results illogical and difficult to interpret. He indicates that "based on adsorption isotherms from similar soils and the quantity of CR+6 found in (Numatic's) soils, the amount in solution (groundwater) may exceed drinking water standards"; yet downgradient monitor wells have shown nondetectable levels of Chrome. Mr. O'Neil recommends resampling the soils, "to determine if CR+6 may be gradually moving but has not reached the monitoring wells yet." These samples should be two composites; (from four to five locations) one at the three foot depth and one at the six foot depth. These two composite samples should be analyzed for pH, Total Chrome, Chrome +6 and Total Nickel.

Also, it will be necessary for you to update your application to reflect your new proposal to add backwash water from a reverse osmosis water treatment system, to your existing process water discharge. I am returning your old application and including a new application for you to fill out. Please make sure that if you sign the application, you need to supply us with a formal letter of authorization signed by a principal executive officer (vice president or president).

Finally, the wastewater characterization we have received from you is not thorough enough. In addition to the parameters you've tested for (dissolved chrome and nickel, and nitrate-nitrogen), you need to sample for: ammonia-nitrogen, nitrite-nitrogen, dissolved aluminum, dissolved cadmium, dissolved zinc, dissolved lead, dissolved iron and specific conductance.

000056

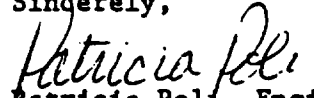
Mr. Matt Murphy

Page Two

August 10, 1987

If you have any questions, please feel free to call me. I hope to hear from you on or before September 30, 1987.

Sincerely,



Patricia Poli, Engineer
Groundwater Permits Section
Waste Management Division
517-335-3381

cc: ✓ Oladipo Oyinson, Detroit District, WMD
Files

000057

The air valve people-worldwide

numatics®

INCORPORATED

1450 N. MILFORD RD. · HIGHLAND, MI 48031 · (313) 887-4111 · TELEX: 297772 NIHD UR · FAX: (313) 887-9190

June 24, 1987

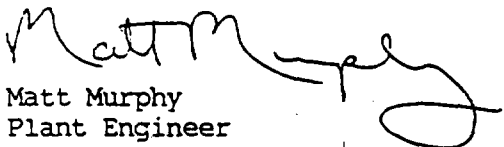
Ms. Patricia Poli
Department of Natural Resources
Stevens T. Mason Building
Box 30028
Lansing, Michigan 48909

Dear Ms. Poli,

In response to your April 9, 1987 letter, please find enclosed a copy of the analysis for water samples taken from the four wells installed by Keck at our 2000 Highland Road plant.

If you have any questions, please feel free to contact me.

Sincerely,


Matt Murphy
Plant Engineer

Enc.
MM/md

JUL 06 1987
GOD-DETROIT DIST.

000058

ENVIRONMENTAL CONTROL TECHNOLOGY CORPORATION

3985 RESEARCH PARK DR.

• ANN ARBOR, MI 48104

• - 313/761-1389

PROJECT Keck - Highland

#29303



DATA SUMMARY SHEET

DATE May, 1987

Sample/Date

Parameter	Units	OW-1D 1786 5/1/87	OW-1S 1787 5/1/87	OW-2 1788 5/1/87	OW-3 1789 5/1/87				
Bicarbonate Alkalinity	mg/l as CaCO ₃	220	190	160	200				
pH	s.u.	7.8	7.7	7.7	7.7				
Ammonia	mg/l	<0.1	<0.1	<0.1	<0.1				
Chloride	mg/l	74	6.5	7.2	34				
Sulfate	mg/l	27	45	16	7.0				
Nitrate	mg/l	<0.1	0.18	0.18	2.2				
Total Phosphorus	mg/l	<0.05	0.21	0.37	0.27				
Hexavalent Chromium	mg/l	<0.01	<0.01	<0.01	<0.01				
Calcium	mg/l	94	65	58	59				
Magnesium	mg/l	22	20	14	15				

000059

SHEET 1 OF 2

ENVIRONMENTAL CONTROL TECHNOLOGY CORPORATION

385 RESEARCH PARK DR.

• ANN ARBOR, MI 48104

• 313/761-1389

PROJECT

Keeck - Highland

#29303



DATA SUMMARY SHEET

DATE May, 1987

Sample/Date

Parameter	Units	OW-1D 1786 5/1/87	OW-1S 1787 5/1/87	OW-2 1788 5/1/87	OW-3 1789 5/1/87				
Sodium	mg/l	25	12	1.9	2.9				
Potassium	mg/l	2.3	2.2	1.5	2.6				
Cadmium	mg/l	<0.02	<0.02	<0.02	<0.02				
Copper	mg/l	<0.02	<0.02	<0.02	<0.02				
Iron	mg/l	<0.05	0.66	0.06	0.07				
Lead	mg/l	<0.02	<0.02	<0.02	<0.02				
Nickel	mg/l	<0.05	<0.05	<0.05	<0.05				
Zinc	mg/l	<0.02	<0.02	<0.02	<0.02				

000060

SHEET 2 OF 2

DIHYDRO ANALYTICAL REPORT

CLIENT: Numatics, Inc.

ADDRESS: 1450 N. Milford Road, Highland, MI 48031-0010

TESTING COMPLETED: 9-3-87

SAMPLE(S) FROM: OUTFALL

MONTH: August, 1987

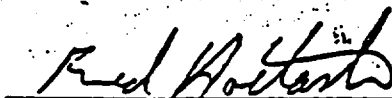
REPORT# L-87-08-14

PARAMETERS

RESULTS

	8-4	8-16	8-21	8-28
Nickel	---	<0.04	---	---
Chromium	---	<0.02	---	---
Chlorides	39	27	30	30
Hardness, total as CaCO ₃	10	12	8	8
Nitrate-Nitrogen	---	<0.10	---	---
Ammonia-Nitrogen	---	2.1	---	---
Nitrite-Nitrogen	---	<0.01	---	---
Aluminum, dissolved	---	<0.1	---	---
Cadmium, dissolved	---	<0.01	---	---
Zinc, dissolved	---	<0.005	---	---
Lead, dissolved	---	<0.05	---	---
Iron, dissolved	---	0.06	---	---
Specific Conductance, μ mhos/cm	---	675	---	---

All results are expressed as mg/l except as noted.



Fred Holtash
Director of Environmental Services

000061

DIHYDRO ANALYTICAL SERVICES

DIhydro Analytical Services, 4541 Fletcher, Wayne, MI (313) 595-0335





DATA SUMMARY SHEET

DATE August, 1987

Parameter	Units	Comp 1-Sa 4444 (2.5'-3')	Comp 1-Sb 4445 (5.5'-6')						
pH	s.u.	7.1	6.9						
Total Solids	%	93	92						
Total Chromium	mg/kg	8.5	6.4						
Total Nitrogen	mg/kg	8.0	8.4						
Hexavalent Chromium	mg/kg	<0.1	<0.1						

RECEIVED

APR 15 1987

HAZARDOUS WASTE DIV

April 9, 1987

Mr. Matthew Murphy
Numatics, Incorporated
1450 N. Milford road
Highland, Michigan 48031

Re: Hydrogeologic Study for Facility
Located at 2000 Highland Road

Dear Mr. Murphy:

I have reviewed the hydrogeologic study conducted by Keck Consulting for the Numatics plant located at 2000 Highland Road. This study was necessary to determine whether the aquifer was usable and to evaluate any impacts on the aquifer from the existing discharge of process water to the drainfield.

The study indicated that the first aquifer is comprised of medium sands with gravel, and discontinuous clay lenses. The water table aquifer is approximately 17 feet below the surface and flows in a southwesterly direction across the site, towards Waterbury Lake. The study confirmed that this aquifer is unprotected, usable, and in a recharge zone, making it especially vulnerable to contamination from surface discharges.

The study also indicated that the soils around the existing tile field have elevated levels of Total Chrome and Hexavalent Chrome (Chrome +6). (Presumably, this is the result of 14 years of process water discharge from the manufacture of small stainless steel parts). This causes concern since Chrome +6 is highly soluble and may be flushed through to the groundwaters by the water draining from the tile field. (Chrome +6 is limited by the United States Environmental Protection Agency (U.S. EPA) to .05 mg/l in drinking water.)

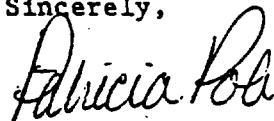
It is for these reasons that you will need to collect some water quality data from the four wells installed by Keck. Each sample should be analyzed for: sodium, potassium, magnesium, sulfate, bicarbonate, chloride, total phosphorus, nitrate-nitrogen, nitrite-nitrogen, ammonia nitrogen, dissolved Chrome +6, dissolved nickel, dissolved lead, dissolved cadmium, dissolved zinc, dissolved copper and dissolved iron.

000063

Mr. Matthew Murphy
April 9, 1987
Page Two (2)

Please respond to this letter on or before May 15, 1987. If you have any questions, feel free to call me. Also, please send our Detroit District Office a copy of the Keck's hydrogeological study.

Sincerely,



Patricia Poli
Hydrogeological Review Unit
Groundwater Quality Division
517-335-3381

cc: Mr. Kevin Cook
Detroit District, GQD
Files

000064

MARCH - NOVEMBER 1988
OAKLAND COUNTY HEALTH DEPARTMENT
PROCESS WELL SURVEY

000065

STATE OF MICHIGAN



JAMES J. BLANCHARD, Governor

DEPARTMENT OF PUBLIC HEALTH

3600 N. LOGAN

P.O. BOX 30035, LANSING, MICHIGAN 48909
GLORIA R. SMITH, Ph.D., M.P.H., F.A.A.N., Director

August 22, 1988

Mr. Dick Beard
Hi-Mill Manufacturing
1704 Highland Road
Highland, Michigan 48031

Dear Mr. Beard:

On July 14, 1988 a representative of the Oakland County Health Division and Michigan Department of Public Health collected water samples from your wells as a part of the groundwater monitoring program. Enclosed please find the laboratory report which lists the parameters tested, test results, standard health maximum contaminant level, if established, and minimum laboratory detection limits.

The results of the partial chemical analysis was satisfactory. The results of the volatile organic analysis revealed 0.004 mg/L benzene in well #1 and 0.001 mg/L trichloroethylene in well #2. The results of the metals analysis revealed 0.15 mg/L barium, 0.006 mg/L arsenic, and 2.0 mg/L iron in well #1 and 0.1 mg/L copper, 0.26 mg/L zinc, 0.007 mg/L lead, 6.5 mg/L iron, 0.19 mg/L barium, and 0.007 mg/L arsenic in well #2.

If you have any questions, feel free to contact Ron Holben at (517) 335-8329 or me at (517) 335-9175.

Sincerely,

A handwritten signature in cursive script, appearing to read "Julie M. Parsons".

Julie M. Parsons, Sanitarian
Ground Water Quality Control Section
Division of Water Supply
Bureau of Environmental and
Occupational Health

JMP:s11

000066



PRINTED ON

STATE OF MICHIGAN



JAMES J. BLANCHARD, Governor

DEPARTMENT OF PUBLIC HEALTH

3500 N. LOGAN

P.O. BOX 30035, LANSING, MICHIGAN 48909

November 7, 1988

Mr. Richard Beard
HiMill Manufacturing
1704 Highland Road
Highland, MI 48031

RE: HiMill Manufacturing Water Supply
WSSN: 20158-63

Dear Mr. Beard:

On November 2, 1988 representatives from the Oakland County Health Department and the Water Supply Division, Michigan Department of Public Health met with you at your request to discuss the water supply serving the HiMill Manufacturing. Those present at the meeting included Karen Kubic and Marty Murthum from the Oakland County Health Department, Ronald Holben from the Water Supply Division, Michigan Department of Public Health, and Richard and Robert Beard representing HiMill Manufacturing.

Water samples collected from the two wells serving HiMill Manufacturing has shown the presence of trichloroethylene and cis-1,2 dichloroethylene. Attached is a summary sheet showing the results of the analysis of water samples which have been collected from the water supply. The presence of these contaminants in the two water wells renders water from these wells unacceptable as a source of drinking water. You had been advised earlier by the Oakland County Health Department that bottled water must be provided for drinking purposes and that employees must be notified about the well contamination.

Your notification to employees must be in writing and must contain information concerning the contaminant found, the concentration of the contaminants found, the availability of health effects, information, and what precautions are being taken to minimize employee exposure to the water, ie, the provision for hauled water. A copy of this notice must be submitted to the Michigan Department of Public Health.

Bottled water is being provided for your employees through the Absopure Water Company. The use of bottle water for drinking purposes must be continued until a water supply approved by the Michigan Department of Public Health has been provided for your facility.

000067



Mr. Richard Beard
Page 2
November 7, 1988

An approved water supply needs to be provided for HiMill Manufacturing. We understand that a municipal source of water is not available. Installation of a new well constructed and isolated to prevent the entrance of contaminants into the well appears to be the most practical solution to provide an approved source of water. Your water well drilling contractor must contact Gary Frick at the Oakland County Health Department (313-858-1322) by November 16, 1988 to discuss specific well construction details and to establish a date for well construction. Once a well has been constructed and approved as a source of drinking water, the use of the two existing contaminated wells must be discontinued and the wells abandoned using materials and methods approved by the Michigan Department of Public Health.

We appreciate your cooperation in resolving this drinking water contamination problem. If representatives from this office or the Oakland County Health Department can be of assistance to you in any way, please don't hesitate to contact us.

Sincerely,



Ronald J. Holben, R.S.
Regional Sanitarian
Division of Water Supply
Bureau of Environmental and
Occupational Health

RJH:sw

cc: Gary Frick, Oakland County Health Department
Julie Parson, GWQC
Geraldine Nowak, Site Assessment, Environmental Response Div., MDNR

000068

Volatile Organic Hydrocarbon Water Sample Summary

Sample Collection Date	Source of Water			Results of Sample Analysis		Sample tap Location	Comments
	Well 1&2 Combined	Well 1 Only	Well 2 Only	Compound Found	Concentration mg/l (ppm)		
3/22/88	X			Chlorodibromomethane Chloroform Dichlorobromomethane Total Trihalomethanes Benzene	.007 .020 .014 .041 .001	Distribution system	Chlorinated water which explains the presence of the Trihalomethanes (first four compounds listed)
5/29/88	X			Nothing Detected		Bathroom Hand Sink	
7/14/88		X		Benzene	.004	Bottom of large steel pressure tank	
7/14/88		X		Trichloroethylene	.001	Near diaphragm tank	
7/1/88	X			Nothing Detected		Bathroom Hand Sink	
10/4/88		X		Cis-1,2 Dichloroethylene Trichloroethylene	.002 .024	Pump discharge line (new tap)	
10/4/88			X	Trichloroethylene	.003	Pump discharge line (new tap)	No chlorine residual in distribution system on this date. Chlorinator not working.
10/12/88		X		Cis-1,2 Dichloroethylene Trichloroethylene	.002 .003	Pump discharge line (new tap)	
10/12/88			X	Trichloroethylene	.012	Pump discharge line (new tap)	
11/2/88		X	X	Samples being analyzed. Results to be forwarded as soon as analysis is complete.		Pump discharge lines (new taps)	
Well #1 - West Well	X			Cis-1,2 Dichloroethylene Trichloroethylene	0.002 0.007	— " —	11/2/88 verbal
Well #2 - East Well		X		Trichloroethylene	0.003	— " —	11/2/88 verbal

NOVEMBER 1988

TECHNA CORPORATION HYDROGEOLOGICAL STUDY

000070



McDOWELL & ASSOCIATES
Geotechnical Engineers

JOB NO. 88-540

LOG OF SOIL BORING NO. 1

PROJECT Environmental Study

LOCATION Highland Site

SURFACE ELEV. DATE 11/28/88

Highland, Michigan

pie Type	Depth	Legend	SOIL DESCRIPTION	Penetration Blows For 6"	Moisture %	Natural Wt. P.C.F.	Dry Den Wt. P.C.F.	Unc. Comp. Strength PSF.	Str. %
	1		0'2" ← ASPHALT						
	2		0'4" ← Very moist fine oxidized brown SAND & GRAVEL, base coarse	5					
A UL	3		← Compact to slightly compact wet fine discolored brown SAND & GRAVEL fill, with stones	2					
	4		3'2" ←						
B UL	5		4'6" ← Firm moist silty sandy organic CLAY, with oxidized streaks, some discolored streaks	4					
	6			5					
	7			9					
C UL	8		← Stiff moist silty oxidized variegated slightly organic CLAY, with wet sand seams or layers, occasional stones	2					
	9			4					
D UL	10		9'0" ←	10					
	11			6					
	12			10					
	13								
	14								
E UL	15			5					
	16			6					
	17			6					
	18		Stiff moist to very moist silty blue CLAY, with oxidized lenses						
	19								
F UL	20			4					
	21			4					
	22			4					
	23								
	24								
	25			4					
				4					
				4					

TYPE OF SAMPLE
D. - DISTURBED
U.L. - UNDIST. LINER
S.T. - SHELBY TUBE
S.S. - SPLIT SPOON
R.C. - ROCK CORE

REMARKS:

000071

Standard Penetration Test - Driving 2" OD Sampler 1' With

GROUND WATER OBSERVATIONS
G.W. ENCOUNTERED AT 0 FT. 4 INS.
G.W. ENCOUNTERED AT 9 FT. 7 INS.
G.W. AFTER COMPLETION FT. INS.
G.W. AFTER HRS FT. INS.



McDOWELL & ASSOCIATES
Geotechnical Engineers

JOB NO. 88-540

LOG OF SOIL BORING NO. 1 continued

PROJECT Environmental Study

LOCATION Highland Site

SURFACE ELEV. DATE 11/28/88 Highland, Michigan

Sample Type	Depth	Legend	SOIL DESCRIPTION	Penetration Blows For 6"	Moisture %	Natural Wt. P.C.F.	Dry Den. Wt. P.C.F.	Unc. Comp. Strength PSF	Str. %
	26		Stiff moist to very moist silty blue CLAY, with oxidized lenses						
	28								
H	30			4					
UL				4					
	32		32'0"	4					
	34		Firm to stiff very moist silty blue CLAY						
I				2					
UL	36			3					
				3					
	38								
J	40			3					
UL				4					
	42			4					
	44								
K			45'0"	7					
UL	46		← Compact wet fine gray SAND & SILT, with discolored lenses & streaks, clay layers	7					
				6					
	48								
L	50		49'9"	4					
UL			← Compact wet medium variegated SAND, with gravel	6					
	52			8					
	54								
M			**	4					
UL	56			6					
			57'0"	9					
	58								
N	60		← Extremely compact wet fine silty brown SAND	13					
UL				25					
	62			36					
			63'0"						
	64		← Extremely stiff moist silty blue CLAY, with wet sand seams or layers						
O				27					
UL	66			54					
				61					
	68								
P	70			67					
UL				58					
	72			--					
	74			28					
				45					
	76		000072	22/3"					

TYPE OF SAMPLE
D. - DISTURBED
U.L. - UNDIST. LINER
S.T. - SHELBY TUBE
S.S. - SPLIT SPOON

REMARKS: ** Sand heavy in Auger 6' - good water
head on top - mixed mud to try thicker heavier
head to hold out sand

Standard Penetration Test - Driving 2" OD Sampler 1' With

GROUND WATER OBSERVATIONS

G.W. ENCOUNTERED AT	45	FT.	0	INS.
G.W. ENCOUNTERED AT	69	FT.	4	INS.
G.W. AFTER COMPLETION		FT.		INS.
G.W. AFTER		FT.		INS.



McDOWELL & ASSOCIATES
Geotechnical Engineers

LOG OF SOIL BORING NO. 1 continued

PROJECT Environmental Study

JOB NO. 88-540

LOCATION Highland Site

SURFACE ELEV. DATE 11/28/88 Highland, Michigan

pile type	Depth	Legend	SOIL DESCRIPTION	Penetration Blows For 6"	Moisture %	Natural Wt. P.C.F.	Dry Den Wt. P.C.F.	Unc. Comp. Strength PSF	Str. %
	77		** Possible sand layers @ 77'0" - 79'0"						
	79								
R				26					
UL	81			47					
	83			23 for 3"					
S	85		84'6" Extremely compact wet fine gray SAND & SILT	27					
UL				38					
	87			45					
	89								
T			91'0" Extremely compact wet coarse brown SAND and GRAVEL, with stones, an occasional fine sand seam or layers	12					
UL	91			17					
	93			23					
	95								
U			105'6" Set 2" PVC Screen Bottom @ 105' USED: 2 x 5' 2" PVC 10 slot screen 10 x 10'3" 2" Riser with cap and plug 1 Bag bentonite Geo-Guard set in well pumped for 3 (three) hours	27					
UL	97			60					
	99			28/3"					
	101			200/3"					
UL				--					
	103			--					
W	105			147					
UL				--					
	107			--					
	109								
	111								
	113								
	115								
	117								
	119								
	121								
	123								
	125								
	127								

TYPE OF SAMPLE
D. - DISTURBED
U.L. - UNDIST. LINER
S.T. - SHELBY TUBE
S.S. - SPLIT SPOON
R.C. - ROCK CORE

REMARKS:

000073
Standard Penetration Test - Driving 2" OD Sampler 1' With
140 lb. Hammer, 2" 20" Sampler, 2" 20" Rod

GROUND WATER OBSERVATIONS
G.W. ENCOUNTERED AT 84 FT. 6 INS.
G.W. ENCOUNTERED AT 91 FT. 0 INS.
G.W. AFTER COMPLETION FT. INS.
G.W. AFTER HRS. FT. INS.



McDOWELL & ASSOCIATES
Geotechnical Engineers

JOB NO. 88-540

LOG OF SOIL BORING NO. 1A

PROJECT Environmental Study

LOCATION Highland Site

SURFACE ELEV. DATE 11/22/88 Highland, Michigan

Soil Type	Depth	Legend	SOIL DESCRIPTION	Penetration Blows For 6"	Moisture %	Natural Wt. P.C.F.	Dry Den Wt. P.C.F.	Unc. Comp. Strength PSF.	Str. %
	1								
	2		Boring 1A the same as Boring #1						
	3		1A ended @ 56'0"						
	4		Set 2" PVC Screen						
	5		Bottom screen @ 55'0"						
	6		Water drilled with 4" Case and 3 7/8"						
	7		Tri-Cone						
	8		USED:						
	9		2 x 5' 2" PVC Screen						
	10		5 x 10' 2" Riser, with						
	11		cap & plug						
	12								
	13		Pumped with Geo-Guard for 2½ hours						
	14								
	15								
	16								
	17								
	18								
	19								
	20								
	21								
	22								
	23								
	24								
	25								

TYPE OF SAMPLE	REMARKS:	GROUND WATER OBSERVATIONS
D. - DISTURBED	000074	G.W. ENCOUNTERED AT FT. INS.
U.L. - UNDIST. LINER		G.W. ENCOUNTERED AT FT. INS.
S.T. - SHELBY TUBE		G.W. AFTER COMPLETION FT. INS.
S.S. - SPLIT SPOON		G.W. AFTER FT. INS.

Standard Penetration Test - Driving 2" OD Sampler 1' With



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JOB NO. 88-540

LOG OF SOIL BORING NO. 2

PROJECT Environmental Study

LOCATION Highland Site

SURFACE ELEV. DATE 11-(23-29)-88 Highland, Michigan

Sample & Type	Depth	Legend	SOIL DESCRIPTION	Penetration Blows For 6"	Moisture %	Natural Wt. P.C.F.	Dry Den Wt. P.C.F.	Unc. Comp. Strength PSF	Str. %
	1		← Very moist mixed brown SAND and CLAY fill, with some gravel & stone						
A	2		1'6" ← Stiff moist silty sandy oxidized brown CLAY, possible fill, with pebbles	4					
UL	3		2'10" ← Stiff moist silty brown CLAY, with oxidized lenses and streaks, occasional pebbles	5					
	4		4'0" ← Very stiff moist silty brown CLAY, with oxidation and silt lenses & streaks, seams	6					
B	5			8					
UL	6			11					
	7			13					
C	8								
UL	9		8'6" ← Very stiff moist silty blue CLAY, with wet sand & silt lenses & seams	6					
	10			8					
D	11			12					
UL	12								
	13		12'0" Very compact wet fine silty gray SAND						
	14								
E	15			8					
UL	16			9					
	17			10					
	18		17'0" Stiff moist silty blue CLAY, with occasional wet silt sand seams						
	19								
F	20			6					
UL	21			7					
	22			6					
	23								
	24		24'0" ← Compact wet fine sandy gray SILT, with clay seams						
UL	25			6					
				6					
				6					

000075

TYPE OF SAMPLE

D. - DISTURBED
U.L. - UNDIST. LINER
S.T. - SHELBY TUBE
S.S. - SPLIT SPOON
R.C. - ROCK CORE

REMARKS:

Drilled to 7' with 3 1/4" Hollow stem, rest of bore wash with 3 7/8" Bit & 10' Case

Standard Penetration Test - Driving 2" OD Sampler 1' With

GROUND WATER OBSERVATIONS

G.W. ENCOUNTERED AT	9	0	INS.
G.W. ENCOUNTERED AT	12	0	INS.
G.W. AFTER COMPLETION	24	0	INS.
G.W. AFTER	HRS.	FT.	INS.



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LOG OF SOIL BORING NO. _____ 2 continued

PROJECT _____ Environmental Study

JOB NO. _____ 88-540 LOCATION _____ Highland Site

SURFACE ELEV. _____ DATE 11-(23-29)-88 Highland, Michigan

Sample & Type	Depth	Legend	SOIL DESCRIPTION	Penetration Blows For 6"	Moisture %	Natural Wt. P.C.F.	Dry Den Wt. P.C.F.	Unc. Comp. Strength PSF.	Str. %
	26		27'0"						
	28								
H	30		Stiff moist silty blue	5					
UL			CLAY, with some wet	6					
	32		silt seams	6					
	34								
I	36			4					
UL				6					
	38		38'0"	8					
I	40		Very stiff moist silty	8					
UL			blue CLAY	9					
	42			11					
	44								
K	46		46'0"	8					
UL				9					
	48			13					
I	50		Extremely compact to very	20					
UL			compact wet medium to	19					
	52		coarse variegated SAND,	18					
	54		with gravel and stones						
M	56			18					
UL				16					
	58			14					
N	60			9					
UL				12					
	62		62'6"	10					
	64		64'6"						
O	66		← Extremely stiff moist silty	18					
UL			very sandy blue CLAY, with	16					
	68		← wet sand streaks or seams,	14					
			stones						
	70		67'0"						
P			← Extremely compact wet fine	34					
UL			clayey gray SAND & GRAVEL	37					
	72		← Extremely compact wet fine	55					
			gray SAND						
	74			21					
UL				42					
	76		76'0"	37					
TYPE OF SAMPLE				GROUND WATER OBSERVATIONS					
D. - DISTURBED				G.W. ENCOUNTERED AT 46 FT. 0 INS.					
U.L. - UNDIST. LINER				G.W. ENCOUNTERED AT 67 FT. 0 INS.					
S.T. - SHELBY TUBE				G.W. AFTER COMPLETION FT. INS.					
S.S. - SPLIT SPOON									
REMARKS:									
000076									



McDOWELL & ASSOCIATES
Geotechnical Engineers

LOG OF SOIL BORING NO. 2 continued

JOB NO. 88-540

PROJECT Environmental Study

LOCATION Highland Site

SURFACE ELEV. DATE 11-(23-29)-88 Highland, Michigan

Sample # & Type	Depth	Legend	SOIL DESCRIPTION	Penetration Blows For 6"	Moisture %	Natural Wt. P.C.F.	Dry Den Wt. P.C.F.	Unc. Comp. Strength PSF	Str. %
	77								
	79								
R				25					
UL	81		Extremely compact wet fine gray SAND & SILT	31					
				32					
	83								
S	85			31					
UL				39					
	87			50					
	89								
				48					
T				67					
UL	91			--					
			92'0"						
	93		← Extremely compact wet fine silty gray SAND, with possible clay seam @ 94'6"						
U	95			31					
UL				55					
	97		96'6"	51					
			← Extremely stiff moist silty blue CLAY, with wet sand silt seams or layers						
	99			19					
			101'0"	26					
UL	101			37					
	103								
W	105			31					
UL				60					
	107		Extremely compact wet medium to coarse gray SAND with some gravel, stones, and occasional rock	60					
	109								
X				55					
UL	111			74					
				--					
	113		113'0"						
	115		Set 2" PVC Screen @ 56'0"						
			USED: 2 2" x 5' Screen						
	117		5 2" x 10' Riser with plug						
	119								
	121								
	123								
	125								
	127								

TYPE OF SAMPLE
D. - DISTURBED
U.L. - UNDIST. LINER
S.T. - SHELBY TUBE
S.S. - SPLIT SPOON

REMARKS:

000077

GROUND WATER OBSERVATIONS

G.W. ENCOUNTERED AT	92	FT.	0	INS.
G.W. ENCOUNTERED AT	101	FT.	0	INS.
G.W. AFTER COMPLETION		FT.		INS.



McDOWELL & ASSOCIATES
Geotechnical Engineers

LOG OF SOIL BORING NO. _____

3

PROJECT Environmental Study

JOB NO. 88-540

LOCATION Highland Site

SURFACE ELEV. _____ DATE 11/30/88 Highland, Michigan

Sample & Type	Depth	Legend	SOIL DESCRIPTION	Penetration Blows For 6"	Moisture %	Natural Wt. P.C.F.	Dry Den Wt. P.C.F.	Unc. Comp. Strength PSF.	Str. %
	1		Medium compact to slightly compact moist to wet medium oxidized brown SAND fill, with stones and some discoloration						
A	2			3					
UL	3			2					
				1					
	4		Loosley compact to slightly compact wet coarse oxidized brown SAND fill, with gravel						
B	5			1/12'					
UL	6			--					
				1					
	7			1					
C	8			2					
UL				1					
	9		Very soft moist silty sandy discolored CLAY, with wet sand seams possible fill						
D	10			1/9"					
UL				--					
	11			1/9"					
	12		Stiff moist silty blue CLAY, with wet silt seams						
	13								
	14								
E	15			7					
UL				8					
	16			8					
	17								
	18								
	19								
F	20		Stiff moist silty blue CLAY, with silt lenses	4					
UL				5					
	21			8					
	22								
	23								
	24								
	25			3					
UL				4					
				5					
TYPE OF SAMPLE			REMARKS: 000078	GROUND WATER OBSERVATIONS					
D.	-	DISTURBED		G.W. ENCOUNTERED AT	0	FT.	7	INS.	
U.L.	-	UNDIST. LINER		G.W. ENCOUNTERED AT	12	FT.	0	INS.	
S.T.	-	SHELBY TUBE		G.W. AFTER COMPLETION		FT.		INS.	
S.S.	-	SPLIT SPOON				FT.		INS.	



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LOG OF SOIL BORING NO. 3 continued

PROJECT Environmental Study

JOB NO. 88-540

LOCATION Highland Site

SURFACE ELEV. _____

DATE 11/30/88

Highland, Michigan

Sample & Type	Depth	Legend	SOIL DESCRIPTION	Penetration Blows For 6"	Moisture %	Natural Wt. P.C.F.	Dry Den Wt. P.C.F.	Unc. Comp. Strength PSF.	Str. %
	26								
	28		Stiff moist silty blue CLAY, with silt lenses						
H	30			3					
UL				4					
	32			6					
	34		34'0"						
I			Compact wet coarse brown SAND, with some gravel, occasional stones	4					
UL	36			5					
			37'0"	8					
	38								
I	40		Extremely compact wet coarse brown SAND, with gravel and stones	13					
UL				14					
	42			12					
	44								
K				12					
UL	46			13					
				15					
	48								
L	50		49'6"	14					
UL			Extremely stiff moist silty sandy blue CLAY, with pebbles, occasional stones	16					
	52			17					
	54								
M				21					
UL	56			33					
				62					
	58								
N	60		59'0"	47					
UL			← Extremely compact very moist fine clayey gray SAND, with gravel & stones	47					
	62		62'0"	47					
	64		← Extremely compact wet coarse gray SAND, with gravel						
O			65'3"	37					
UL	66			28					
				21					
	68		← Extremely stiff moist silty blue CLAY, with pebbles						
P	70			28					
UL				35					
	72		72'0"	47					
			← Extremely stiff moist silty sandy blue CLAY with gravelly streaks or seams, pebbles						
UL	74			60					
				69					
	76			--					
TYPE OF SAMPLE O. - DISTURBED U.L. - UNDIST. LINER S.T. - SHELBY TUBE S.S. - SPLIT SPOON				REMARKS: 000079					
				GROUND WATER OBSERVATIONS G.W. ENCOUNTERED AT 34 FT. 0 INS. G.W. ENCOUNTERED AT 62 FT. 0 INS. G.W. AFTER COMPLETION FT. INS.					





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LOG OF SOIL BORING NO. 3 continued

PROJECT Environmental Study

JOB NO. 88-540 LOCATION Highland Site

SURFACE ELEV. _____ DATE 11/31/88 Highland, Michigan

Sample Type	Depth	Legend	SOIL DESCRIPTION	Penetration Blows For 6"	Moisture %	Natural Wt. P.C.F.	Dry Den Wt. P.C.F.	Unc. Comp. Strength PSF	Str. %
	77		78'6" ← Extremely stiff moist silty very sandy gravelly blue CLAY, hardpan, with rocks						
	79								
R									
UL	81			160					
				--					
	83			--					
S	85			207 1/5"					
UL				--					
	87		87'0"	--					
			← Extremely compact wet coarse gray SAND & GRAVEL with stones, boulders, and heavy gravel						
	89								
T									
UL	91			250 1/5"					
				--					
	93			--					
U	95			241 1/5"					
UL				--					
	97			--					
	99								
			100'0"	200 1/6"					
UL	101			--					
				--					
	103								
			Set 2" Screen @ 93'0"						
	105		USED: 2 2" x 5' Screen,						
			with plug						
	107		9 2" x 10' Riser						
	109								
	111		Pumped with Geo-Guard						
			for 2½ hours						
	113								
	115								
	117								
	119								
	121								
	123								
	125								
	127								
TYPE OF SAMPLE			REMARKS:	GROUND WATER OBSERVATIONS					
D. - DISTURBED			000080	G.W. ENCOUNTERED AT 87 FT. 0 INS.					
U.L. - UNDIST. LINER				G.W. ENCOUNTERED AT FT. INS.					
S.T. - SHELBY TUBE				G.W. AFTER COMPLETION FT. INS.					
S.S. - SPLIT SPOON				G.W. AFTER HRS FT. INS.					
R.C. - ROCK CORE									
			Standard Penetration Test - Driving 2" OD Sampler 1' With						



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JOB NO. 88-540

LOG OF SOIL BORING NO. 3A

PROJECT Environmental Study

LOCATION Highland Site

SURFACE ELEV. DATE 12/2/88 Highland, Michigan

Sample Type	Depth	Legend	SOIL DESCRIPTION	Penetration Blows For 6"	Moisture %	Natural Wt. P.C.F.	Dry Den Wt. P.C.F.	Unc. Comp. Strength PSF	Str. %
	1		Boring 3A the same as Boring #3						
	2		3A ended @ 50'0"						
	3								
	4		Set 2" PVC Screen						
	5		USED: 2 2" x 5' Screen with plug						
	6		4 2" x 10' Riser						
	7								
	8		Pumped with Geo-Guard for 2½ hours						
	9								
	10								
	11								
	12								
	13								
	14								
	15								
	16								
	17								
	18								
	19								
	20								
	21								
	22								
	23								
	24								
	25								

TYPE OF SAMPLE
D. - DISTURBED
U.L. - UNDIST. LINER
S.T. - SHELBY TUBE
S.S. - SPLIT SPOON
S.C. - ROCK CORE

REMARKS:

000081

Standard Penetration Test - 3" OD Sampler 1" Min.

GROUND WATER OBSERVATIONS

G.W. ENCOUNTERED AT	FT.	INS.
G.W. ENCOUNTERED AT	FT.	INS.
G.W. AFTER COMPLETION	FT.	INS.



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LOG OF SOIL BORING NO. _____

4

PROJECT Environmental Study

JOB NO. 88-540

LOCATION Highland Site

SURFACE ELEV. _____

DATE 12/5/88

Highland, Michigan

Sample & Type	Depth	Legend	SOIL DESCRIPTION	Penetration Blows For 6"	Moisture %	Natural Wt. P.C.F.	Dry Den Wt. P.C.F.	Unc. Comp. Strength PSF	Str. %
			0'3" ← ASPHALT						
1			0'8" ← Very moist medium discolored SAND & GRAVEL, base coarse						
2									
3			← Stiff moist silty oxidized brown CLAY, with sand and pebbles						
4									
5									
6			5'6"						
7									
8									
9									
10									
11									
12									
13									
14									
15									
16									
17									
18									
19									
20									
21									
22									
23									
24									
25									

TYPE OF SAMPLE	REMARKS:	GROUND WATER OBSERVATIONS
D. - DISTURBED		G.W. ENCOUNTERED AT FT. INS.
U.L. - UNDIST. LINER		G.W. ENCOUNTERED AT FT. INS.
S.T. - SHELBY TUBE		G.W. AFTER COMPLETION FT. INS.
S.S. - SPLIT SPOON		G.W. AFTER COMPLETION FT. INS.

000087

Standard Penetration Test - Driving 3" OD Sampler 1' WGS



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JOB NO. 88-540

LOG OF SOIL BORING NO. 5

PROJECT Environmental Study

LOCATION Highland Site

SURFACE ELEV. DATE 12/5/88 Highland, Michigan

Sample Type	Depth	Legend	SOIL DESCRIPTION	Penetration Blows For 6"	Moisture %	Natural Wt. P.C.F.	Dry Den Wt. P.C.F.	Unc. Comp. Strength PSF	Str. %
	1		0'2" ← ASPHALT						
	2		← Moist fine organic brown CLAY & SAND fill, with stones and some vegetation						
	3								
	4		3'6" ← Very moist fine silty clayey organic brown SAND						
	5		4'6" ← Moist silty sandy clayey organic brown PEAT, possible topsoil, with vegetation						
	6		5'6"						
	7								
	8								
	9								
	10								
	11								
	12								
	13								
	14								
	15								
	16								
	17								
	18								
	19								
	20								
	21								
	22								
	23								
	24								
	25								

- TYPE OF SAMPLE
D. - DISTURBED
U.L. - UNDIST. LINER
S.T. - SHELBY TUBE
S.S. - SPLIT SPOON
R.C. - ROCK CORE

REMARKS:

000083

Standard Penetration Test - Driving 2" OD Sampler 1' With

GROUND WATER OBSERVATIONS

G.W. ENCOUNTERED AT	FT.	INS.
G.W. ENCOUNTERED AT	FT.	INS.
G.W. AFTER COMPLETION	FT.	INS.
G.W. AFTER	HRS. FT.	INS.

Sample description - Blank

Sample ID = 88-12-23-1

Parameter: Purgeables(601/02)

Matrix: Water

Date analyzed: December 5, 1988

Method: Purge & Trap

Compound	Concentration ug/l	Detection Limit ug/l
Dichlorodifluoromethane	ND	< 1.0
Chloromethane	ND	< 5.0
Vinyl chloride	ND	< 5.0
Chloroethane	ND	< 5.0
Bromoethane	ND	< 4.0
1,1-Dichloroethene	ND	< 0.4
Methylene chloride	ND	< 2.0
t-1,2-Dichloroethene	ND	< 0.2
1,1-Dichloroethane	ND	< 0.3
c-1,2-Dichloroethene	ND	< 0.2
Chloroform	2.7	< 1.0
1,1,1-Trichloroethane	ND	< 0.2
Carbon tetrachloride	ND	< 0.2
Benzene	ND	< 0.4
1,2-Dichloroethane	ND	< 0.2
Trichloroethene	ND	< 0.5
1,2-Dichloropropane	ND	< 0.1
Bromodichloromethane	ND	< 0.5
2-Chloroethylvinyl ether	ND	< 0.5
t-1,3-Dichloropropene	ND	< 1.0
Toluene	ND	< 0.2
c-1,3-Dichloropropene	ND	< 1.0
1,1,2-Trichloroethane	ND	< 1.0
Tetrachloroethene	ND	< 1.0
Dibromochloromethane	ND	< 1.0
Chlorobenzene	ND	< 0.2
Ethylbenzene	ND	< 0.2
m+p-Xylene	ND	< 0.2
o-Xylene	ND	< 0.2
Bromoform	ND	< 0.9
1,1,2,2-Tetrachloroethane	ND	< 0.7
1,3-Dichlorobenzene	ND	< 0.4
1,4-Dichlorobenzene	ND	< 0.4
1,2-Dichlorobenzene	ND	< 0.4

Analyst: R. S. Lynch

RS

000084

DIHYDRO ANALYTICAL SERVICES

Dihydro Analytical Services, 4541 Fletcher, Wayne, MI, (313) 595-0335

A Division of DIHYDRO

Sample description - Blank A

Sample ID = 88-12-23-2

Parameter: Purgeables(601/02)

Matrix: Water

Date analyzed: December 5, 1988

Method: Purge & Trap

Compound	Concentration ug/l	Detection Limit ug/l
Dichlorodifluoromethane	ND	< 1.0
Chloromethane	ND	< 5.0
Vinyl chloride	ND	< 5.0
Chloroethane	ND	< 5.0
Bromoethane	ND	< 4.0
1,1-Dichloroethene	ND	< 0.4
Methylene chloride	ND	< 2.0
t-1,2-Dichloroethene	ND	< 0.2
1,1-Dichloroethane	ND	< 0.3
c-1,2-Dichloroethene	ND	< 0.2
Chloroform	2.5	< 1.0
1,1,1-Trichloroethane	ND	< 0.2
Carbon tetrachloride	ND	< 0.2
Benzene	ND	< 0.4
1,2-Dichloroethane	ND	< 0.2
Trichloroethene	ND	< 0.5
1,2-Dichloropropane	ND	< 0.1
Bromodichloromethane	ND	< 0.5
2-Chloroethylvinyl ether	ND	< 0.5
t-1,3-Dichloropropene	ND	< 1.0
Toluene	ND	< 0.2
c-1,3-Dichloropropene	ND	< 1.0
1,1,2-Trichloroethane	ND	< 1.0
Tetrachloroethene	ND	< 1.0
Dibromochloromethane	ND	< 1.0
Chlorobenzene	ND	< 0.2
Ethylbenzene	ND	< 0.2
m+p-Xylene	ND	< 0.2
o-Xylene	ND	< 0.2
Bromoform	ND	< 0.9
1,1,2,2-Tetrachloroethane	ND	< 0.7
1,3-Dichlorobenzene	ND	< 0.4
1,4-Dichlorobenzene	ND	< 0.4
1,2-Dichlorobenzene	ND	< 0.4

Analyst: R. S. Lynch

RS

000085

DIHYDRO ANALYTICAL SERVICES

Dihydro Analytical Services, 4541 Fletcher, Wayne, MI, (313) 595-0335

A Division of DIHYDRO

Sample description - Blank 2

Sample ID = 88-12-23-3

Parameter: Purgeables(601/02)

Matrix: Water

Date analyzed: December 5, 1988

Method: Purge & Trap

Compound	Concentration ug/l	Detection Limit ug/l
Dichlorodifluoromethane	ND	< 1.0
Chloromethane	ND	< 5.0
Vinyl chloride	ND	< 5.0
Chloroethane	ND	< 5.0
Bromoethane	ND	< 4.0
1,1-Dichloroethene	ND	< 0.4
Methylene chloride	ND	< 2.0
t-1,2-Dichloroethene	ND	< 0.2
1,1-Dichloroethane	ND	< 0.3
c-1,2-Dichloroethene	ND	< 0.2
Chloroform	2.7	< 1.0
1,1,1-Trichloroethane	ND	< 0.2
Carbon tetrachloride	ND	< 0.2
Benzene	ND	< 0.4
1,2-Dichloroethane	ND	< 0.2
Trichloroethene	ND	< 0.5
1,2-Dichloropropane	ND	< 0.1
Bromodichloromethane	ND	< 0.5
2-Chloroethylvinyl ether	ND	< 0.5
t-1,3-Dichloropropene	ND	< 1.0
Toluene	ND	< 0.2
c-1,3-Dichloropropene	ND	< 1.0
1,1,2-Trichloroethane	ND	< 1.0
Tetrachloroethene	ND	< 1.0
Dibromochloromethane	ND	< 1.0
Chlorobenzene	ND	< 0.2
Ethylbenzene	ND	< 0.2
m+p-Xylene	ND	< 0.2
o-Xylene	ND	< 0.2
Bromoform	ND	< 0.9
1,1,2,2-Tetrachloroethane	ND	< 0.7
1,3-Dichlorobenzene	ND	< 0.4
1,4-Dichlorobenzene	ND	< 0.4
1,2-Dichlorobenzene	ND	< 0.4

Analyst: R. S. Lynch

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DIHYDRO ANALYTICAL SERVICES

Dihydro Analytical Services, 4541 Fletcher, Wayne, MI, (313) 595-0335

A Division of DIHYDRO

Sample description - Blank 2A

Sample ID = 88-12-23-4

Parameter: Purgeables(601/02)

Matrix: Water

Date analyzed: December 5, 1988

Method: Purge & Trap

Compound	Concentration ug/l	Detection Limit ug/l
Dichlorodifluoromethane	ND	< 1.0
Chloromethane	ND	< 5.0
Vinyl chloride	ND	< 5.0
Chloroethane	ND	< 5.0
Bromoethane	ND	< 4.0
1,1-Dichloroethene	ND	< 0.4
Methylene chloride	ND	< 2.0
t-1,2-Dichloroethene	ND	< 0.2
1,1-Dichloroethane	ND	< 0.3
c-1,2-Dichloroethene	ND	< 0.2
Chloroform	2.3	< 1.0
1,1,1-Trichloroethane	ND	< 0.2
Carbon tetrachloride	ND	< 0.2
Benzene	ND	< 0.4
1,2-Dichloroethane	ND	< 0.2
Trichloroethene	ND	< 0.5
1,2-Dichloropropane	ND	< 0.1
Bromodichloromethane	ND	< 0.5
2-Chloroethylvinyl ether	ND	< 0.5
t-1,3-Dichloropropene	ND	< 1.0
Toluene	ND	< 0.2
c-1,3-Dichloropropene	ND	< 1.0
1,1,2-Trichloroethane	ND	< 1.0
Tetrachloroethene	ND	< 1.0
Dibromochloromethane	ND	< 1.0
Chlorobenzene	ND	< 0.2
Ethylbenzene	ND	< 0.2
m+p-Xylene	ND	< 0.2
o-Xylene	ND	< 0.2
Bromoform	ND	< 0.9
1,1,2,2-Tetrachloroethane	ND	< 0.7
1,3-Dichlorobenzene	ND	< 0.4
1,4-Dichlorobenzene	ND	< 0.4
1,2-Dichlorobenzene	ND	< 0.4

Analyst: R. S. Lynch

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DIHYDRO ANALYTICAL SERVICES

Dihydro Analytical Services, 4541 Fletcher, Wayne, MI, (313) 595-0335

A Division of

DIHYDRO

Sample description - Sample 1

Sample ID = 88-12-23-5

Parameter: Purgeables(601/02)

Date analyzed: December 5, 1988

Matrix: Water

Method: Purge & Trap

Compound	Concentration ug/l	Detection Limit ug/l
Dichlorodifluoromethane	ND	< 1.0
Chloromethane	ND	< 5.0
Vinyl chloride	ND	< 5.0
Chloroethane	ND	< 5.0
Bromoethane	ND	< 4.0
1,1-Dichloroethene	ND	< 0.4
Methylene chloride	ND	< 2.0
t-1,2-Dichloroethene	ND	< 0.2
1,1-Dichloroethane	ND	< 0.3
c-1,2-Dichloroethene	ND	< 0.2
Chloroform	ND	< 1.0
1,1,1-Trichloroethane	ND	< 0.2
Carbon tetrachloride	ND	< 0.2
Benzene	ND	< 0.4
1,2-Dichloroethane	ND	< 0.2
Trichloroethene	ND	< 0.5
1,2-Dichloropropane	ND	< 0.1
Bromodichloromethane	ND	< 0.5
2-Chloroethylvinyl ether	ND	< 0.5
t-1,3-Dichloropropene	ND	< 1.0
Toluene	ND	< 0.2
c-1,3-Dichloropropene	ND	< 1.0
1,1,2-Trichloroethane	ND	< 1.0
Tetrachloroethene	ND	< 1.0
Dibromochloromethane	ND	< 1.0
Chlorobenzene	ND	< 0.2
Ethylbenzene	ND	< 0.2
m+p-Xylene	ND	< 0.2
o-Xylene	ND	< 0.2
Bromoform	ND	< 0.9
1,1,2,2-Tetrachloroethane	ND	< 0.7
1,3-Dichlorobenzene	ND	< 0.4
1,4-Dichlorobenzene	ND	< 0.4
1,2-Dichlorobenzene	ND	< 0.4

Analyst: R. S. Lynch

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DIHYDRO ANALYTICAL SERVICES

Dihydro Analytical Services, 4541 Fletcher, Wayne, MI. (313) 595-0335

A Division of DIHYDRO

Sample description - Sample 1A

Sample ID = 88-12-23-6

Parameter: Purgeables(601/02)

Matrix: Water

Date analyzed: December 5, 1988

Method: Purge & Trap

Compound	Concentration ug/l	Detection Limit ug/l
Dichlorodifluoromethane	ND	< 1.0
Chloromethane	ND	< 5.0
Vinyl chloride	ND	< 5.0
Chloroethane	ND	< 5.0
Bromoethane	ND	< 4.0
1,1-Dichloroethene	ND	< 0.4
Methylene chloride	ND	< 2.0
t-1,2-Dichloroethene	ND	< 0.2
1,1-Dichloroethane	ND	< 0.3
c-1,2-Dichloroethene	ND	< 0.2
Chloroform	ND	< 1.0
1,1,1-Trichloroethane	ND	< 0.2
Carbon tetrachloride	ND	< 0.2
Benzene	ND	< 0.4
1,2-Dichloroethane	ND	< 0.2
Trichloroethene	ND	< 0.5
1,2-Dichloropropane	ND	< 0.1
Bromodichloromethane	ND	< 0.5
2-Chloroethylvinyl ether	ND	< 0.5
t-1,3-Dichloropropene	ND	< 1.0
Toluene	ND	< 0.2
c-1,3-Dichloropropene	ND	< 1.0
1,1,2-Trichloroethane	ND	< 1.0
Tetrachloroethene	ND	< 1.0
Dibromochloromethane	ND	< 1.0
Chlorobenzene	ND	< 0.2
Ethylbenzene	ND	< 0.2
m+p-Xylene	ND	< 0.2
o-Xylene	ND	< 0.2
Bromoform	ND	< 0.9
1,1,2,2-Tetrachloroethane	ND	< 0.7
1,3-Dichlorobenzene	ND	< 0.4
1,4-Dichlorobenzene	ND	< 0.4
1,2-Dichlorobenzene	ND	< 0.4

Analyst: R. S. Lynch *RL*

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DIHYDRO ANALYTICAL SERVICES

Dihydro Analytical Services, 4541 Fletcher, Wayne, MI, (313) 595-0335

A Division of DIHYDRO

Sample description - Sample 2

Sample ID = 88-12-23-7

Parameter: Purgeables(601/02)

Matrix: Water

Date analyzed: December 5, 1988

Method: Purge & Trap

Compound	Concentration ug/l	Detection Limit ug/l
Dichlorodifluoromethane	ND	< 1.0
Chloromethane	ND	< 5.0
Vinyl chloride	ND	< 5.0
Chloroethane	ND	< 5.0
Bromoethane	ND	< 4.0
1,1-Dichloroethene	ND	< 0.4
Methylene chloride	ND	< 2.0
t-1,2-Dichloroethene	ND	< 0.2
1,1-Dichloroethane	ND	< 0.3
c-1,2-Dichloroethene	ND	< 0.2
Chloroform	ND	< 1.0
1,1,1-Trichloroethane	ND	< 0.2
Carbon tetrachloride	ND	< 0.2
Benzene	ND	< 0.4
1,2-Dichloroethane	ND	< 0.2
Trichloroethene	ND	< 0.5
1,2-Dichloropropane	ND	< 0.1
Bromodichloromethane	ND	< 0.5
2-Chloroethylvinyl ether	ND	< 0.5
t-1,3-Dichloropropene	ND	< 1.0
Toluene	ND	< 0.2
c-1,3-Dichloropropene	ND	< 1.0
1,1,2-Trichloroethane	ND	< 1.0
Tetrachloroethene	ND	< 1.0
Dibromochloromethane	ND	< 1.0
Chlorobenzene	ND	< 0.2
Ethylbenzene	ND	< 0.2
m+p-Xylene	ND	< 0.2
o-Xylene	ND	< 0.2
Bromoform	ND	< 0.9
1,1,2,2-Tetrachloroethane	ND	< 0.7
1,3-Dichlorobenzene	ND	< 0.4
1,4-Dichlorobenzene	ND	< 0.4
1,2-Dichlorobenzene	ND	< 0.4

Analyst: R. S. Lynch

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DIHYDRO ANALYTICAL SERVICES

Dihydro Analytical Services, 4541 Fletcher, Wayne, MI, (313) 595-0335

A Division of DIHYDRO
SERVICES

Sample description - Sample 3

Sample ID = 88-12-23-9

Parameter: Purgeables(601/02)

Matrix: Water

Date analyzed: December 5, 1988

Method: Purge & Trap

Compound	Concentration ug/l	Detection Limit ug/l
Dichlorodifluoromethane	ND	< 1.0
Chloromethane	ND	< 5.0
Vinyl chloride	ND	< 5.0
Chloroethane	ND	< 5.0
Bromoethane	ND	< 4.0
1,1-Dichloroethene	ND	< 0.4
Methylene chloride	ND	< 2.0
t-1,2-Dichloroethene	ND	< 0.2
1,1-Dichloroethane	ND	< 0.3
c-1,2-Dichloroethene	ND	< 0.2
Chloroform	ND	< 1.0
1,1,1-Trichloroethane	ND	< 0.2
Carbon tetrachloride	ND	< 0.2
Benzene	ND	< 0.4
1,2-Dichloroethane	ND	< 0.2
Trichloroethene	ND	< 0.5
1,2-Dichloropropane	ND	< 0.1
Bromodichloromethane	ND	< 0.5
2-Chloroethylvinyl ether	ND	< 0.5
t-1,3-Dichloropropene	ND	< 1.0
Toluene	ND	< 0.2
c-1,3-Dichloropropene	ND	< 1.0
1,1,2-Trichloroethane	ND	< 1.0
Tetrachloroethene	ND	< 1.0
Dibromochloromethane	ND	< 1.0
Chlorobenzene	ND	< 0.2
Ethylbenzene	ND	< 0.2
m+p-Xylene	ND	< 0.2
o-Xylene	ND	< 0.2
Bromoform	ND	< 0.9
1,1,2,2-Tetrachloroethane	ND	< 0.7
1,3-Dichlorobenzene	ND	< 0.4
1,4-Dichlorobenzene	ND	< 0.4
1,2-Dichlorobenzene	ND	< 0.4

Analyst: R. S. Lynch

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DIHYDRO ANALYTICAL SERVICES

Dihydro Analytical Services, 4541 Fletcher, Wayne, MI, (313) 595-0335

A Division of DIHYDRO

Sample description - Sample 3A

Sample ID = 88-12-23-10

Parameter: Purgeables(601/02)

Matrix: Water

Date analyzed: December 5, 1988

Method: Purge & Trap

Compound	Concentration ug/l	Detection Limit ug/l
Dichlorodifluoromethane	ND	< 1.0
Chloromethane	ND	< 5.0
Vinyl chloride	ND	< 5.0
Chloroethane	ND	< 5.0
Bromoethane	ND	< 4.0
1,1-Dichloroethene	ND	< 0.4
Methylene chloride	ND	< 2.0
t-1,2-Dichloroethene	ND	< 0.2
1,1-Dichloroethane	ND	< 0.3
c-1,2-Dichloroethene	ND	< 0.2
Chloroform	ND	< 1.0
1,1,1-Trichloroethane	ND	< 0.2
Carbon tetrachloride	ND	< 0.2
Benzene	ND	< 0.4
1,2-Dichloroethane	ND	< 0.2
Trichloroethene	ND	< 0.5
1,2-Dichloropropane	ND	< 0.1
Bromodichloromethane	ND	< 0.5
2-Chloroethylvinyl ether	ND	< 0.5
t-1,3-Dichloropropene	ND	< 1.0
Toluene	ND	< 0.2
c-1,3-Dichloropropene	ND	< 1.0
1,1,2-Trichloroethane	ND	< 1.0
Tetrachloroethene	ND	< 1.0
Dibromochloromethane	ND	< 1.0
Chlorobenzene	ND	< 0.2
Ethylbenzene	ND	< 0.2
m+p-Xylene	ND	< 0.2
o-Xylene	ND	< 0.2
Bromoform	ND	< 0.9
1,1,2,2-Tetrachloroethane	ND	< 0.7
1,3-Dichlorobenzene	ND	< 0.4
1,4-Dichlorobenzene	ND	< 0.4
1,2-Dichlorobenzene	ND	< 0.4

Analyst: R. S. Lynch

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DIHYDRO ANALYTICAL SERVICES

Dihydro Analytical Services, 4541 Fletcher, Wayne, MI. (313) 595-0335

A Division of DIHYDRO

SAMPLE ID = 88-12-23-10Duplicate

Parameter: PURGEABLES(601&2)

Date analyzed: December 5, 1988

Matrix: Water

ANALYST: R. S. Lynch

Method: Purge & trap

Volume purged: 5 ml

Compound	Concentration			Mean	Detection Limit
	1 ug/l	2 ug/l	Diff ug/l		
Dichlorodifluoromethan	ND	ND			< 1.0
Chloromethane	ND	ND			< 5.0
Vinyl chloride	ND	ND			< 5.0
Chloroethane	ND	ND			< 5.0
Bromoethane	ND	ND			< 4.0
1,1-Dichloroethene	ND	ND			< 0.4
Methylene chloride	ND	ND			< 2.0
t-1,2-Dichloroethene	ND	ND			< 0.2
1,1-Dichloroethane	ND	ND			< 0.3
c-1,2-Dichloroethene	ND	ND			< 0.2
Chloroform	ND	ND			< 1.0
1,1,1-Trichloroethane	ND	ND			< 0.2
Carbon tetrachloride	ND	ND			< 0.2
Benzene	ND	ND			< 0.4
1,2-Dichloroethane	ND	ND			< 0.2
Trichloroethene	ND	ND			< 0.5
1,2-Dichloropropane	ND	ND			< 0.1
Bromodichloromethane	ND	ND			< 0.5
2-Chloroethylvinyl eth	ND	ND			< 0.5
t-1,3-Dichloropropene	ND	ND			< 1.0
Toluene	ND	ND			< 0.2
c-1,3-Dichloropropene	ND	ND			< 1.0
1,1,2-Trichloroethane	ND	ND			< 1.0
Tetrachloroethene	ND	ND			< 1.0
Dibromochloromethane	ND	ND			< 1.0
Chlorobenzene	ND	ND			< 0.2
Ethylbenzene	ND	ND			< 0.2
m+p-Xylene	ND	ND			< 0.2
o-Xylene	ND	ND			< 0.2
Bromoform	ND	ND			< 0.9
1,1,2,2-Tetrachloroeth	ND	ND			< 0.7
1,3-Dichlorobenzene	ND	ND			< 0.4
1,4-Dichlorobenzene	ND	ND			< 0.4
1,2-Dichlorobenzene	ND	ND			< 0.4

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DIHYDRO ANALYTICAL SERVICES

Dihydro Analytical Services, 4541 Fletcher, Wayne, MI, (313) 595-0335

A Division of DIHYDRO

SAMPLE ID = 88-12-23-10 Spike

Parameter: PURGEABLES(601&2)

Date analyzed: December 5, 1988

Matrix: Water

Analyst: R. S. Lynch

Method: Purge & trap

Volume purged: 5 ml

Volume of spike: .005 ml

Compound	Mean	Spike	True Spike	%
	ug/l	ug/l	ug/l	Recovery
Methylene chloride	0.0	30.6	27.8	110.1
1,1-Dichloroethane	0.0	24.1	24.2	99.6
Chloroform	0.0	36.8	30.5	120.7
1,1,1-Trichloroethane	0.0	26.1	27.5	94.9
Benzene	0.0	40.2	40.0	100.5
1,2-Dichloroethane	0.0	26.2	26.4	99.2
Trichloroethene	0.0	29.2	28.6	102.1
1,2-Dichloropropane	0.0	25.4	29.7	85.5
1,1,2-Trichloroethane	0.0	30.4	30.9	98.4
Tetrachloroethene	0.0	46.7	42.6	109.6
Chlorobenzene	0.0	38.5	44.9	85.7
Ethylbenzene	0.0	46.0	48.2	95.4
m+p-Xylene	0.0	37.7	41.9	90.0
o-Xylene	0.0	30.4	32.7	93.0
1,1,2,2-Tetrachloroethane	0.0	33.5	32.0	104.7
1,3-Dichlorobenzene	0.0	22.6	31.5	71.7
1,4-Dichlorobenzene	0.0	29.8	31.7	94.0
1,2-Dichlorobenzene	0.0	51.0	50.5	101.0

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DIHYDRO ANALYTICAL SERVICES

Dihydro Analytical Services, 4541 Fletcher, Wayne, MI, (313) 595-0335

A Division of DIHYDRO

SAMPLE ID = Method Standard Spike

Parameter: PURGEABLES(601&2)

Date analyzed: December 5, 1988
 Matrix: Water Analyst: R. S. Lynch
 Method: Purge & trap Volume purged: 5 ml
 Volume of spike: .005 ml

Compound	Mean	Spike	True Spike	% Recovery
	ug/l	ug/l	ug/l	
1,1-Dichloroethane	0.0	27.2	24.2	112.4
Chloroform	0.0	39.8	30.5	130.5
1,1,1-Trichloroethane	0.0	28.5	27.5	103.6
Benzene	0.0	43.2	40.0	108.0
1,2-Dichloroethane	0.0	25.4	26.4	96.2
Trichloroethene	0.0	29.4	28.6	102.8
1,2-Dichloropropane	0.0	27.4	29.7	92.3
1,1,2-Trichloroethane	0.0	30.4	30.9	98.4
Tetrachloroethene	0.0	50.5	42.6	118.5
Chlorobenzene	0.0	50.3	44.9	111.9
Ethylbenzene	0.0	51.8	48.2	107.5
m+p-Xylene	0.0	43.5	41.9	103.8
o-Xylene	0.0	42.5	32.7	130.0
1,1,2,2-Tetrachloroethane	0.0	31.8	32.0	99.4
1,3-Dichlorobenzene	0.0	27.8	31.5	88.3
1,4-Dichlorobenzene	0.0	36.5	31.7	115.1
1,2-Dichlorobenzene	0.0	62.5	50.5	123.8

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DIHYDRO ANALYTICAL SERVICES

Dihydro Analytical Services, 4541 Fletcher, Wayne, MI. (313) 595-0335

A Division of **DIHYDRO**

APPENDIX B
LABORATORY STANDARD OPERATING PROCEDURES (Non-CLP)

ENCOTEC

Hexavalent Chromium (HCR)
METHOD NUMBER: 3110

A. Introduction

1.Applicability: This method is applicable to waters and wastewaters and water extracted soils.

2.Purpose of Testing: Chromium salts are used in many industrial processes and may contaminate potable water through discharge of wastewater.

3.Method Detection Limit: The method detection limit is 5 ug/l. The working linear range is 5-100 ug/l.

4.Reference Methods: US EPA SW846, 3rd ed. Method 7196.

5.Summary of Method: Hexavalent chromium is determined colorimetrically by the reaction with diphenylcarbazide in an acid solution, producing a red-violet color.

6.Interferences: Some metals interfere, but the method is almost completely chromium specific.

7.Sample Collection and Preservation: Collect at least 250 ml of sample in a plastic bottle. Cool the sample to 4 degrees celsius upon collection. If a soil is to be collected fill an 8 oz glass jar and cool to 4 degrees celsius.

7. Holding Time: 24 hours.

8.Safety Precaution: General safety precautions.

B. Apparatus

1. Spectrophotometer for use at 540 nm.

2. Class A pipets and volumetric flasks.

3. pH paper.

4. Standard lab glassware.

C. Procedure

1. Reagents:

a. Stock chromium solution: Dissolve 141.4 mg of potassium dichromate in SQ water and dilute to 1 liter. This is a 50 mg/l solution. Keep refrigerated.

b. Diphenylcarbazide solution: Dissolve 250 mg of 1,5- diphenylcarbazide in 50 ml of acetone. This solution is light sensitive. Store in a light resistant bottle. Make fresh daily.

c. Sulfuric acid, 10%: Add 10 ml of concentrated H2SO4 to SQ water and dilute to 100 ml.

2. Standards:

1000 ug/l: 20 ml of 50 mg/l->100ml

100 ug/l: 10 ml of 1000 ug/l->100ml

50 ug/l: 5 ml of 1000 ug/l-> 100ml

20 ug/l: 2 ml of 1000 ug/l->100ml

10 ug/l: 10 ml of 100 ug/l->100ml

5 ug/l: 5 ml of 100 ug/l->100ml

0 ug/l: Blank - Reagent Blank

3. Calibration Verification Source: Secondary standard made at 25 ug/l.

4. Spiking Protocol: Take 1 ml of 1000 ug/l standard and add to 49 ml of sample for a 20 ug/l spike with a dilution factor of 0.98.

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5. Method:

a. For soils take 10 g of sample and 100 ml of SQ water and mix for 1 hour. Filter through 45 micron filter paper. Save the filtrate.

b. For blanks, standards, and soil filtrates, pipet 50 ml of sample into a beaker. Adjust the pH to 2 with 10% H₂SO₄. Usually 0.2 ml of sample is sufficient.

c. Using an eppendorf, pipet 1.0 ml of diphenylcarbazide solution to each aliquot. Wait 10 minutes for color development. Transfer aliquot to the cuvette and measure the absorbance at 540 nm.

D. Calculations

1. Run a linear regression on the standard curve. Calculate concentration from this curve. The correlation coefficient must be greater than or equal to 0.9950 for curve to be valid.

E. Quality Control

1. Blank: Analyze one blank (0.3% H₂SO₄) after the Initial calibration verification, and after each continuing verification. It must be \leq DL or analysis is to be terminated and the problem corrected.

2. Lab Control Sample: One Lab Control Sample (LCS) will be performed with each analytical set. Prepare by spiking blank using the spiking protocol. It must be within $\pm 10\%$ of true value, or the analysis is to be terminated and corrective action taken.

3. Matrix Spike: One matrix spike is to be performed for every 20 samples or per analytical set, whichever is most frequent. It is prepared as per the spiking protocol. It must be within 85-115% recovery or the data is flagged.

4. Matrix Duplicate: One matrix duplicate is to be performed for every 20 samples or per analytical set, whichever is most frequent. It must have an RPD of 10%, or flagged accordingly.

Ammonia Nitrogen (NH₃)
Method Number: 3120

A. Introduction

1.Applicability: This method is applicable to waters and wastewaters.

2.Purpose of Testing: Ammonia is a natural element in waters and wastewaters. It is of interest in waters because it is a component of the biological nitrogen cycle. In wastewaters, chlorine treatment is not effective until all ammonia has been oxidized.

3.Method Detection Limit: The method detection limit is 0.05 mg/l. The linear working range is 0.05-2.0 mg/l.

4.Reference Methods: US EPA 600-4/79. Method 350.1.

5.Summary of Method: Ammonia nitrogen reacts with sodium phenoxide to produce indophenol, a blue colored compound. EDTA is added to eliminate the precipitation of calcium and magnesium hydroxides. Sodium nitroprusside is added to intensify the blue color.

6.Interferences: Calcium and magnesium ions in large quantities may precipitate during analysis. Turbidity and color in the sample may interfere. Turbid samples should be filtered prior to analysis. Colored samples may be read with and without color reagent, the difference used to determine the concentration of analyte.

7.Sample Collection and Preservation: Collect at least 250 ml of sample. Add enough sulfuric acid to make the final concentration 0.3% H₂SO₄ in the sample. Cool the sample at 4 degrees celsius.

7. Holding Time: 28 days.

8.Safety Precaution: General lab safety protocols.

B. Apparatus

1. Technicon TRAACS 800 with appropriate light filters.
2. Class A pipets, and volumetric flasks.

C. Procedure

1. Reagents:

a. Alkaline Phenol: Add 83 g of liquified phenol to about 800 ml of SQ water. While cooling under tap water, add 96.0 g of sodium hydroxide with slowly swirling. Cool to room temperature, dilute to one liter with SQ water and mix thoroughly. Retain for 2 weeks.

b. Sodium Hypochlorite: Dilute 86 ml of sodium hypochlorite (commercially available) to 100 ml of SQ water and mix. Prepare fresh weekly.

c. Sodium Nitroprusside: Dissolve 1.1 g of sodium nitroprusside in about 600 ml of SQ water. Dilute to one liter with SQ water and mix. Retain for one month.

d. Disodium EDTA: Dissolve 41.0 g of EDTA in about 800 ml of SQ water. Adjust the pH to 10.5 with 50% NaOH. Dilute to one liter. Add 3 ml of Brij-35 and mix. Prepare daily.

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2. Standards:

Stock Standard: 3.819 g NH_4Cl in one liter of 0.3% H_2SO_4 = 1000 mg/l.

Working Standard: 2 ml of 1000 mg/l diluted to 100 ml = 20 mg/l.

Linear Standards

2 mg/l: 10 ml of 20mg/l \rightarrow 100ml

1 mg/l: 5 ml of 20mg/l \rightarrow 100ml

0.5 mg/l: 2.5 ml of 20 mg/l \rightarrow 100ml

0.1 mg/l: 10 ml of 1 mg/l \rightarrow 100ml

0.05 mg/l: 5 ml of 1 mg/l \rightarrow 100ml

0.0 mg/l: Reagent Blank

3. Calibration Verification Source: Secondary standard made at 0.5 mg/l.

4. Spiking Protocol: Add 0.1 ml of 20 mg/l stock to 4 ml of sample which equals a 0.5 mg/l spike and a dilution factor of 0.98.

5. Method:

a. Set up the TRAACS as per Figure 1.

b. Set up analysis protocol on computer.

c. Establish a baseline with all reagents in place.

d. Establish the base and gain with the high standard.

e. Activate autosampler and begin analysis.

D. Calculations

1. The computer will report mV readings for every standard, blank, and sample, corrected for baseline drift. Perform a linear regression on the standards to establish a calibration curve. Verify that the calibration verification standard and continuing calibration standards meet the required window.

2. Calculate the concentration of the samples, spikes, and duplicates from the calibration curve. Verify and report all percent recoveries and RPDs.

E. Quality Control

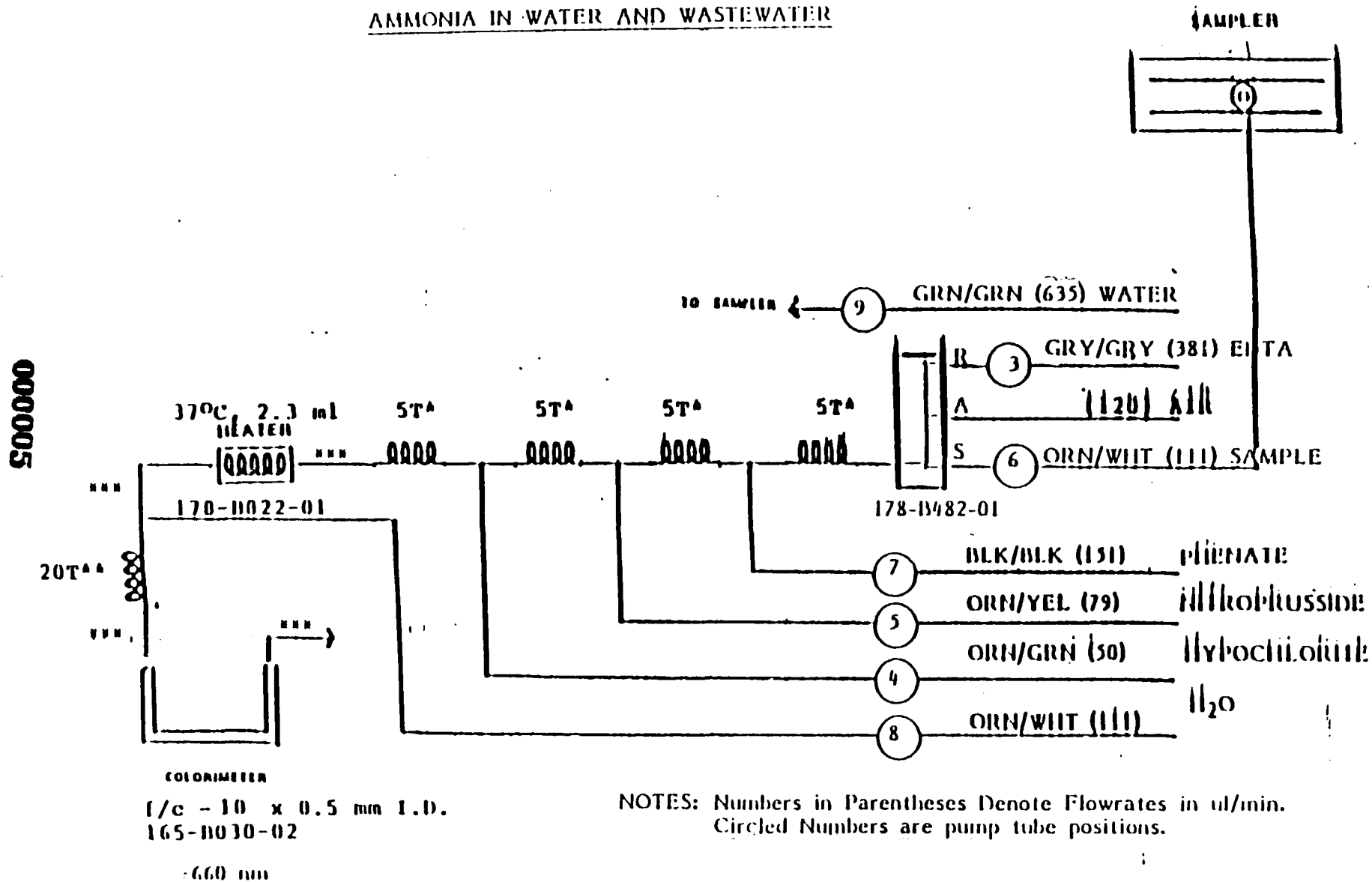
1. Blank: Analyze one blank (0.3% H_2SO_4) after the Initial calibration verification, and after each continuing verification. It must be \leq DL or analysis is to be terminated and the problem corrected.

2. Lab Control Sample: One Lab Control Sample (LCS) will be performed with each analytical set. Prepare by spiking blank using the spiking protocol. It must be within $\pm 10\%$ of true value, or the analysis is to be terminated and corrective action taken.

3. Matrix Spike: One matrix spike is to be performed for every 20 samples or per analytical set, whichever is most frequent. It is prepared as per the spiking protocol. It must be within 85-115% recovery or the data is flagged.

4. Matrix Duplicate: One matrix duplicate is to be performed for every 20 samples or per analytical set, whichever is most frequent. It must have an RPD of 10%, or flagged accordingly.

ENVIRONMENTAL MULTITEST CARTRIDGE
AMMONIA IN WATER AND WASTEWATER



Nitrate/Nitrite Nitrogen(NPN)
METHOD NUMBER: 3030

A. Introduction

1.Applicability: This method is applicable to waters and wastewaters.

2.Purpose of Testing: Nitrates are an essential component of the biological nitrogen cycle in natural waters. Nitrite can react with amines in acidic media to form nitrosamines, many of which are carcinogens.

3.Method Detection Limit: The method detection limit is 0.05 mg/l. The linear working range is 0.05-2.0 mg/l.

4.Reference Methods: US EPA 600, 4/79, method 353.2.

5.Summary of Method: Nitrate is reduced to nitrite using a cadmium reduction coil. The nitrites react under acidic conditions with sulfanilamide to form a diazo compound that then couples with N-1-Naphthylethylenediamine dihydrochloride to form a reddish-purple color that is measured at 520nm.

6.Interferences: High concentrations of metals may interfere, such as iron and copper. Samples which contain oil and grease may coat the cadmium, thereby limiting the reduction.

7.Sample Collection and Preservation: Collect at least 250 ml of sample in a plastic bottle. Add enough concentrated sulfuric acid to make the final concentration 0.3% H₂SO₄. Cool at 4 degrees celsius.

7. Holding Time: 28 days.

8.Safety Precaution: General lab safety practice.

B. Apparatus

1. Technicon TRAACS 800 with light filters.

2. Class A pipets and volumetric flasks.

C. Procedure

1. Reagents:

a. Triton X-100: Commercially available.

b. Imidizole Buffer: Dissolve 6.81 g of imidizole in about 900 ml of SQ water. Adjust pH to 7.5 with hydrochloric acid. Dilute to one liter. Retain until consumed.

c. Copper Sulfate Solution (0.01M): Dilute 5.0 g of copper sulfate in about 600 ml of SQ water. Dilute to two liters. Retain until consumed.

d. Stock Copper Sulfate(0.001M): Dilute 50 ml of copper sulfate solution to 500 ml.

e. Working Imidizole(0.05M): Add 0.5 ml of stock copper sulfate solution to 50 ml of imidizole buffer. Dilute to 100 ml with SQ water, add 0.1 ml of Triton X-100 and mix thoroughly. Prepare fresh daily.

f. Working SAN Solution: Add 5.0g of sulfanilamide to one liter volumetric flask containing 600 ml of SQ water. Add 0.5 ml of 50% Triton X-100 and mix well. Transfer to a light resistant container. Store in a refrigerator when not in use.

g. Working NED Solution: Dissolve 0.5 g of N-1-naphtylethylenediamine dihydrochloride in about 600 ml of SQ water. Dilute to one liter and add 0.5 ml 50% Triton X-100.

000006

Transfer to light resistant container. Store in refrigerator when not in use.

h. Hydrochloric Acid (2N): Carefully add 330 ml of concentrated HCL to about 600 ml of SQ water. Cool to room temperature and dilute to two liters with SQ water. Add 0.5 ml of 50% Triton X-100.

i. Nitric Acid (2N): Carefully add 250 ml of concentrated nitric acid to about 600 ml of SQ water. Cool to room temperature and dilute to 2 liters with SQ water.

j. System Wash Solution: Add 0.5 ml of 50% Triton X-100 to one liter of SQ water and mix.

k. Copper Activating Solution: Dilute 50 ml of stock copper sulfate, 0.01M, to 100 ml of SQ water. Add 0.1 ml of 50% Triton X-100 and mix.

2. Standards:

Stock Nitrate Standard: Take 8 ml of Nitrogen APHA standard solution and dilute to 100 ml of 0.3% H₂SO₄. This is a 20 mg/l standard.

Working Standards

20 mg/l: 10 ml of 20 mg/l → 100ml

1 mg/l: 5 ml of 20 mg/l → 100ml

0.5 mg/l: 2.5 ml of 20 mg/l → 100ml

0.1 mg/l: 10 ml of 1 mg/l → 100ml

0.05 mg/l: 5 ml of 1 mg/l → 100ml

0.0 mg/l: Reagent Blank

3. Calibration Verification Source: Secondary standard made at 0.5 mg/l.

4. Spiking Protocol: Add 0.1 ml of 20 mg/l to 3.9 ml of sample to equal a 0.50 mg/l spike and a dilution factor of 0.98.

5. Method:

a. Before operating the system, clean the cadmium coil and perform the activation procedure. When the recovery of the nitrate standard falls outside of 90-110%, repeat the activation procedure. If the procedure does not resolve the problem, clean the coil.

b. Clean the coil by drawing 1 ml of 2N HNO₃ through it. Transfer 20 ml of HCl to the beaker and 20 ml of SQ water into another. Draw out 5 ml of acid and 5 ml of water by touching the end of the coil to the surface of each liquid. Repeat until both liquids are consumed. Finally draw 20 ml of water through the coil for a rinse.

c. Activate the column pumping through the buffer line 2N HCl for 1 minute, then copper activating solution for 2 minutes, and then 2N HCl for 5 minutes. Place the working buffer line back into its container and allow 5-10 minutes for equilibration.

d. Set up the TRAACS manifold as in figure 1..

e. Set up the autosampler protocol on the computer.

f. Establish a baseline and gain using the high standard.

g. Activate the autosampler and begin analysis.

D. Calculations

1. The computer will report mV readings for every standard, blank, and sample, corrected for baseline drift. Perform a linear regression on the standards to establish a calibration curve. Verify that the calibration verification standard and continuing calibration verification standards meet the required window.

2. Calculate the concentration of the samples, spikes, and duplicates from the calibration curve. Verify and report all percent recoveries and RPDs.

E. Quality Control

1. Blank: Analyze one blank (0.3% H₂SO₄) after the Initial calibration verification, and after each continuing verification. It must be \leq DL or analysis is to be terminated and the problem corrected.

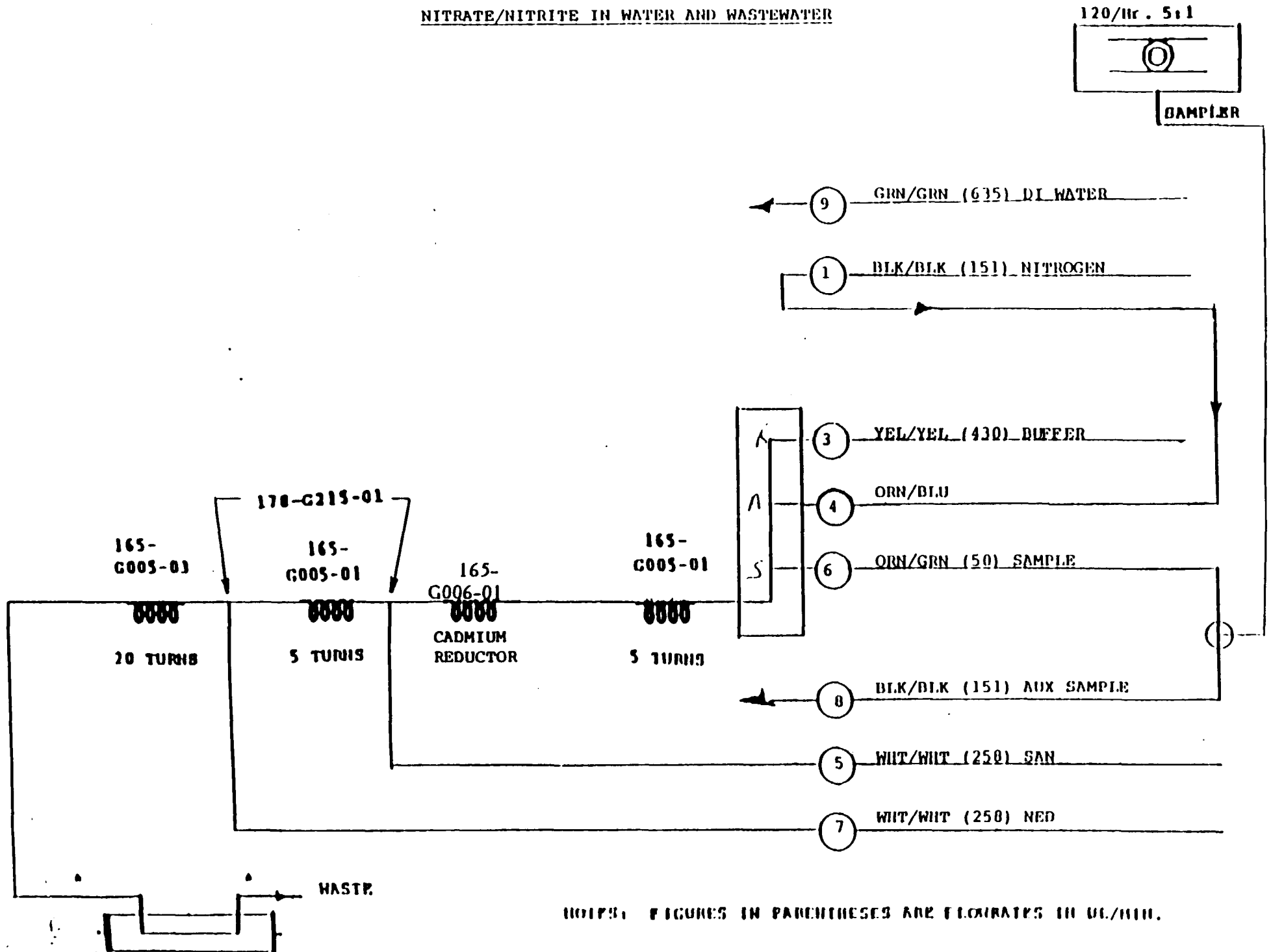
2. Lab Control Sample: One Lab Control Sample (LCS) will be performed with each analytical set. Prepare by spiking blank using the spiking protocol. It must be within $\pm 10\%$ of true value, or the analysis is to be terminated and corrective action taken.

3. Matrix Spike: One matrix spike is to be performed for every 20 samples or per analytical set, whichever is most frequent. It is prepared as per the spiking protocol. It must be within 85-115% recovery or the data is flagged.

4. Matrix Duplicate: One matrix duplicate is to be performed for every 20 samples or per analytical set, whichever is most frequent. It must have an RPD of 10%, or flagged accordingly.

NITRATE/NITRITE IN WATER AND WASTEWATER

120/Hr . 5:1



NOTES: FIGURES IN PARENTHESES ARE FLOWRATES IN ML/MIN.

DATA DELIVERABLES Data will be delivered in a package comprized of both results and quality assurance records. It will be grouped in sets of twenty samples of similar matrix, or all samples of similar matrix arriving in a single two-week period, whichever group is the smaller. This sample delivery group (SDG) will be defined by the client's designation for the first sample in the SDG. Contents of the data package are listed below.

Case narrative The delivered data package will include a case narrative, which will describe sample preparation and analysis. In addition, the narrative will contain reports of problems encountered in the course of sample preparation and analysis, with corrective action taken and resolution.

Cover page Following the case narrative will be a listing of samples analysed, identified by both client and Encotec designations. Arrangement of the list will be by order of increasing Encotec number.

Form I In addition, the package will provide summaries of sample analyses, in the same order as that of the sample list, as well as the following QC sample analyses' summaries:

Form II - initial and continuing calibration blanks, and preparation blank

Form III - initial and continuing calibration verifications,

Form V - spike sample recoveries, one for each SDG

Form VI - duplicate sample analyses, with relative percent differences, one or two for each SDG

Form VII - a laboratory control sample, prepared with each analytical set.

Further, the package will have clear, legible copies of all raw data used to generate the above summaries, including instruments' printouts, laboratory bench sheets, etc. Also provided will be fair copies of all instrument logbooks. (A logbook will include an instrument's serial number, purchase date, date brought on line, maintenance and repair history for the period of service to this project, and daily entries, including analyst i.d., parameter measured, instrument settings, and any other information of interest, particularly comments on the samples analysed.)

QUALITY CONTROL REQUIREMENTS: QC requirements under this contract will be satisfied as follows:

Initial and continuing calibration blanks - shall read less than the absolute value of the reading obtained for the lowest standard used in the calibration curve, or for the instrument detection limit, whichever is lower; continuing calibration blanks will be read after every ten analyses (an analysis is defined as any solution or sample other than instrument calibration standards, initial calibration verification standard, continuing calibration verification standards, initial calibration blank and continuing calibration blanks). Should an initial calibration blank read outside the above criterion, analysis will not proceed until corrective action has been taken and is successful. When a continuing calibration blank fails criterion, corrective action must be taken, and all analyses between the failure and the most recent successful continuing calibration blank must be performed

again.

Initial calibration verification (ICV) and continuing calibration verifications (CCV)'s - ICV shall be used for CCV's, which will be taken after every ten analyses. Preferentially, the ICV shall be made up from a source traceable to EPA, NBIS, or other reference source; at a minimum the ICV shall be based on a different stock solution than that used to generate the calibration standards. Both ICV and CCV's will return responses within $\pm 10\%$ of the true value specified by the reference sample's supplier. Should the ICV fall outside the control limits, analysis of samples shall not proceed until corrective action generates a result within those limits. Should a CCV fail criterion, once corrective action is taken, all analyses performed between the failure and the most recent successful continuing calibration verification shall be repeated.

Matrix spikes - these are duplicates of samples to which a known amount of the analyte of interest has been added prior to preparation and analysis of the sample. One sample in each SDG will be so treated. Spike sample recovery percent is calculated as follows:

$$\% \text{ recovery} = \frac{(SSR - SR)}{SA} \times 100$$

where SSR = Spiked Sample Result
SR = Sample Result
SA = Spike Added
when sample concentration is $< DL$,
us SR = 0 for % recovery calculations only

Control limits for percent recovery are 85% - 115%. Should a matrix spike fall outside these limits, it will be indicated on both Form I and Form V.

Duplicate samples - one sample in each SDG or one sample in every ten, whichever frequency is the greater, will be analyzed twice. Only the first result, called the sample, will be reported

on Form I (the average of the two repetitions will not be reported as a sample concentration). The second result will be called the duplicate, and the relative percent difference between the two will be calculated as follows:

$$RPD = -\frac{|S-D|}{\left[\frac{S+D}{2}\right]} \times 100$$

where RPD = Relative Percent Difference
S = Sample Result
D = Duplicate Result

when either S or D or both is (are) <DL,
the RPD is defined as not calculable (NC)

The control limit for relative percent difference is 10%. Duplicates which fail to meet this criterion will be flagged on both Form I and Form VI.

Preparation blank - an aliquot of distilled, deionized water carried through the preparation and analysis procedure. Analysis should show results less than the value of the lowest standard in the calibration curve. Results that do not satisfy the criterion call for corrective action, before further analysis of samples is undertaken.

Laboratory control sample - an aliquot of distilled deionized water, spiked with a known concentration of the analyte of interest, and carried through the preparation and analysis procedure. Percent recovery is calculated as follows:

$$\% \text{ recovery} = \frac{LCS}{SA} \times 100$$

where LCS = Spiked Prep Blank Result
SA = Spike Added

Again, results that fall outside control limits call for corrective action.

TABLE OF RAW DATA CODES

ICV = Initial Calibration Verification Standard
CCV = Continuing Calibration Verification Standard
ICB = Initial Calibration Blank
CCB = Continuing Calibration Blank
PB = Preparation Blank
LCS = Laboratory Control Sample
XXXXS = Matrix Spike for Sample XXXX
XXXXD = Duplicate for Sample XXXX

Multiples of any of these will be followed by a number (i.e.,
CCV1, CCB2,....., etc.)

TABLE OF REPORT FORM DATA AND QC CODES

U = Analyte is below method detection limit (MDL)

N = Matrix spike recovery not within control limits

* = Duplicate relative percent difference is not within control limits

NR = Not required for analysis

MDL = Method Detection Limit

AC = Automated Spectrophotometric

C = Manual Spectrophotometric

COVER PAGE-INORGANIC ANALYSES DATA PACKAGE

Lab Name:

Contract:

Lab Code:

Case No.:

SAS No.:

SDG No:

SOW No.:

EPA SAMPLE NO.

LAB SAMPLE NO.

Comments:

Release of the data contained in this hardcopy data package and in the computer-readable data submitted on floppy diskette has been authorized by the Laboratory Manager or the Manager's designee, as verified by the following signature.

Lab Manager:

Date:

FORM I

SAMPLE NO:
DATE:

INORGANIC ANALYSIS DATA SHEET

LAB NAME:

CASE NO:

LAB SAMPLE ID:

QC REPORT NO:

ELEMENTS IDENTIFIED AND MEASURED

MATRIX: WATER: SOIL: SLUDGE: OTHER:

UG/L OR MG/KG DRY WEIGHT (CIRCLE ONE)

CHROMIUM(VI)
AMMONIA-N
NITRATE-N
PERCENT SOLIDS(%)

COMMENTS:

000017

FORM II
QC REPORT NO.:
ICB/CCB RECOVERY

LAB NAME:

CASE NO:

DATE:
UNITS:

COMPOUND
NAME

ICB

MATRIX:
CCB1

CCB2

CCB3

CCB4

CHROMIUM(VI)
AMMONIA-N
NITRATE-N

000018

FORM III
QC REPORT NO.:
ICV/CCV RECOVERY

LAB NAME:
DATE:
UNITS:

CASE NO:

COMPOUND NAME	TRUE VALUE	MATRIX: FOUND	%REC	FOUND	%REC
CHROMIUM(VI)					
AMMONIA-N					
NITRATE-N					

FORM V
QC REPORT NO.:
SPIKE SAMPLE RECOVERY

LAB NAME:

DATE:

CASE NO:

SAMPLE NO.:

LAB SAMPLE NO.:

UNITS:

MATRIX:

COMPOUND

SPIKED SAMPLE
RESULT

SAMPLE
RESULT

SPIKED
ADDED

%R

CHROMIUM(VI)

AMMONIA-N

NITRATE-N

FORM VI
QC REPORT NO.:
DUPLICATES

LAB NAME:

CASE NO:

DATE:

SAMPLE NO.:

LAB SAMPLE NO.:

UNITS:

MATRIX:

COMPOUND

SAMPLE(S)

DUPLICATE(D)

RPD

CHROMIUM(VI)

AMMONIA-N

NITRATE-N

000021

McDOWELL AND ASSOCIATES

000022

June 16, 1989

The physical properties of selected soil samples will be determined in the soils laboratory of McDowell & Associates in Ferndale, Michigan. The proposed properties to be tested are listed below.

Moisture Content

Atterberg Limits

Sieve and Grain Size Distribution Tests

Permeability Tests

The results of this testing will be used to establish the engineering properties of the underlying soils and to confirm and augment visual and textural examination of the samples.

Before soil testing, soil samples will be prepared based on the methods described in ASTM D-421 "Standard Method for Dry Preparation of Soil Samples for Particle-size Analysis and Determination of Soil Constants". After preparation of samples, Atterberg Limit tests will be performed in accordance with ASTM D-4318, "Standard Test Method for Liquid Limit, Plastic Limit, and Plasticity Index of Soils".

Grain size distribution will be determined in accordance with ASTM D-422, "Standard Method for Particle-size Analysis of Soils". The moisture content of soil samples will be determined in accordance with ASTM D-2216, "Standard Method of Laboratory Determination of Moisture Content of Soil."

June 15, 1989

Two methods of Permeability testing will be performed depending on the type of soil materials encountered. ASTM D-2434 "Permeability of Granular Soils (constant head)" will be used. Falling head permeability will be performed using equipment designed and manufactured by McDowell & Associates. There is no standard test procedure (ASTM) for the falling head permeability test.

Slug tests will be performed in the field utilizing the method proposed by Hvorslev (1951). Both falling head and constant head tests will be performed. Minimum well diameter will be 2" and minimum screen length will be 3'.

000024



Standard Test Method for Liquid Limit, Plastic Limit, and Plasticity Index of Soils¹

This standard is issued under the fixed designation D 4318; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ϵ) indicates an editorial change since the last revision or reapproval.

This test method has been approved for use by agencies of the Department of Defense and for listing in the DoD Index of Specifications and Standards.

Scope

1.1 This test method covers the determination of the liquid limit, plastic limit, and the plasticity index of soils as defined in Section 3.

1.1.1 Two procedures for preparing test specimens and two procedures for performing the liquid limit are provided as follows:

- 1 Multipoint test using a wet preparation procedure, described in Sections 10.1, 11, and 12.
- 2 Multipoint test using a dry preparation procedure, described in Sections 10.2, 11, and 12.
- 3 One-point test using a wet preparation procedure, described in Sections 13, 14, and 15.
- 4 One-point test using a dry preparation procedure, described in Sections 13, 14, and 15.

1.1.2 The procedure to be used shall be specified by the requesting authority. If no procedure is specified, Procedure A shall be used.

NOTE 1—Prior to the adoption of this test method, a curved grooving tool was specified as part of the apparatus for performing the liquid limit test. The curved tool is not considered to be as accurate as the flat tool described in 6.2 since it does not control the depth of the soil in the liquid limit cup. However, there are some data which indicate that the liquid limit is slightly increased when the flat tool is used instead of the curved tool.

1.2 The plastic limit test procedure is described in Sections 16, 17, and 18. The plastic limit test is performed on a soil prepared for the liquid limit test. In effect, there are two procedures for preparing test specimens for the plastic limit test.

1.3 The procedure for calculating the plasticity index is given in Section 19.

1.4 The liquid limit and plastic limit of soils (along with shrinkage limit) are often collectively referred to as the Atterberg limits in recognition of their formation by Swedish geotechnologist, A. Atterberg. These limits distinguish the characteristics of the several consistency states of plastic soils.

1.5 As used in this test method, soil is any natural material of mineral or organic materials, mixtures of such

materials, or artificial mixtures of aggregates and natural mineral and organic particles.

1.4 The multipoint liquid limit procedure is somewhat more time consuming than the one-point procedure when both are performed by experienced operators. However, the one-point procedure requires the operator to judge when the test specimen is approximately at its liquid limit. In cases where this is not done reliably, the multipoint procedure is as fast as the one-point procedure and provides additional precision due to the information obtained from additional trials. It is particularly recommended that the multipoint procedure be used by inexperienced operators.

1.5 The correlations on which the calculations of the one-point procedure are based may not be valid for certain soils, such as organic soils or soils from a marine environment. The liquid limit of these soils should therefore be determined by the multipoint procedure (Procedure A).

1.6 The liquid and plastic limits of many soils that have been allowed to dry before testing may be considerably different from values obtained on undried samples. If the liquid and plastic limits of soils are used to correlate or estimate the engineering behavior of soils in their natural moist state, samples should not be permitted to dry before testing unless data on dried samples are specifically desired.

1.7 The composition and concentration of soluble salts in a soil affect the values of the liquid and plastic limits as well as the water content values of soils (see Method D 2216). Special consideration should therefore be given to soils from a marine environment or other sources where high soluble salt concentrations may be present. The degree to which the salts present in these soils are diluted or concentrated must be given consideration if meaningful results are to be obtained.

1.8 Since the tests described herein are performed only on that portion of a soil which passes the 425- μ m (No. 40) sieve, the relative contribution of this portion of the soil to the properties of the sample as a whole must be considered when using these tests to evaluate the properties of a soil.

1.9 The values stated in acceptable metric units are to be regarded as the standard. The values given in parentheses are for information only.

1.10 *This standard may involve hazardous materials, operations, and equipment. This standard does not purport to address all of the safety problems associated with its use. It is the responsibility of whoever uses this standard to consult and establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

This test method is under the jurisdiction of ASTM Committee D-18 on Soil and Rock and is the direct responsibility of Subcommittee D18.03 on Texture, Structure, and Density Characteristics of Soils.

This edition approved Oct. 26, 1984. Published December 1984. Originally published as D 4318 - 83. Last previous edition D 4318 - 83¹.

2. Referenced Documents

2.1 ASTM Standards:

- C 702 Methods for Reducing Field Samples of Aggregate to Testing Size²
- D 75 Practice for Sampling Aggregates⁴
- D 420 Practice for Investigating and Sampling Soil and Rock for Engineering Purposes⁴
- D 653 Terminology Relating to Soil, Rock, and Contained Fluids⁴
- D 1241 Specification for Materials for Soil-Aggregate Subbase, Base, and Surface Courses⁴
- D 2216 Method for Laboratory Determination of Water (Moisture) Content of Soil, Rock, and Soil-Aggregate Mixtures⁴
- D 2240 Test Method for Rubber Property—Durometer Hardness⁵
- D 2487 Test Method for Classification of Soils for Engineering Purposes⁴
- D 2488 Practice for Description and Identification of Soils (Visual-Manual Procedure)⁴
- D 3282 Practice for Classification of Soils and Soil-Aggregate Mixtures for Highway Construction Purposes⁴
- E 11 Specification for Wire-Cloth Sieves for Testing Purposes⁶
- E 319 Methods of Testing Single-Arm Balances⁶
- E 898 Method of Testing Top-Loading, Direct-Reading Laboratory Scales and Balances⁶

3. Definitions

3.1 *Atterberg limits*—originally, seven “limits of consistency” of fine-grained soils were defined by Albert Atterberg. In current engineering usage, the term usually refers only to the liquid limit, plastic limit, and in some references, the shrinkage limit.

3.2 *consistency*—the relative ease with which a soil can be deformed.

3.3 *liquid limit (LL)*—the water content, in percent, of a soil at the arbitrarily defined boundary between the liquid and plastic states. This water content is defined as the water content at which a pat of soil placed in a standard cup and cut by a groove of standard dimensions will flow together at the base of the groove for a distance of 13 mm (½ in.) when subjected to 25 shocks from the cup being dropped 10 mm in a standard liquid limit apparatus operated at a rate of 2 shocks per second.

NOTE 2—The undrained shear strength of soil at the liquid limit is considered to be 2 ± 0.2 kPa (0.28 psi).

3.4 *plastic limit (PL)*—the water content, in percent, of a soil at the boundary between the plastic and brittle states. The water content at this boundary is the water content at which a soil can no longer be deformed by rolling into 3.2 mm (⅛ in.) in diameter threads without crumbling.

3.5 *plastic soil*—a soil which has a range of water content over which it exhibits plasticity and which will retain its shape on drying.

3.6 *plasticity index (PI)*—the range of water content which a soil behaves plastically. Numerically, it is difference between the liquid limit and the plastic limit.

3.7 *liquidity index*—the ratio, expressed as a percent, of (1) the natural water content of a soil minus its plastic limit, to (2) its plasticity index.

3.8 *activity number (A)*—the ratio of (1) the plasticity index of a soil to (2) the percent by weight of particles having an equivalent diameter smaller than 0.002 mm.

4. Summary of Method

4.1 The sample is processed to remove any material retained on a 425-μm (No. 40) sieve. The liquid limit is determined by performing trials in which a portion of the sample is spread in a brass cup, divided in two by a grooving tool, and then allowed to flow together from the shock caused by repeatedly dropping the cup in a standard mechanical device. The multipoint liquid limit, Procedures A and B, requires three or more trials over a range of water contents to be performed and the data from the trials plotted or calculated to make a relationship from which the liquid limit is determined. The one-point liquid limit, Procedures C and D, uses the data from two trials at one water content multiplied by a correction factor to determine the liquid limit.

4.2 The plastic limit is determined by alternately pressing together and rolling into a 3.2 mm (⅛ in.) diameter thread a small portion of plastic soil until its water content is reduced to a point at which the thread crumbles and is no longer able to be pressed together and rerolled. The water content of the soil at this stage is reported as the plastic limit.

4.3 The plasticity index is calculated as the difference between the liquid limit and the plastic limit.

5. Significance and Use

5.1 This test method is used as an integral part of several engineering classification systems to characterize the fine-grained fractions of soils (see Test Method D 2487 and Practice D 3282) and to specify the fine-grained fraction of construction materials (see Specification D 1241). The liquid limit, plastic limit, and plasticity index of soils are also used extensively, either individually or together with other soil properties to correlate with engineering behavior such as compressibility, permeability, compactibility, shrinkage, and shear strength.

5.2 The liquid and plastic limits of a soil can be used with the natural water content of the soil to express its relative consistency or liquidity index and can be used with the percentage finer than 2-μm size to determine its activity number.

5.3 The one-point liquid limit procedure is frequently used for routine classification purposes. When greater precision is required, as when used for the acceptance of material or for correlation with other test data, the multipoint procedure should be used.

5.4 These methods are sometimes used to evaluate weathering characteristics of clay-shale materials. When subjected to repeated wetting and drying cycles, the liquid limits of these materials tend to increase. The amount of increase is considered to be a measure of a shale's susceptibility to weathering.

² Annual Book of ASTM Standards, Vol 04.02.

³ Annual Book of ASTM Standards, Vols 04.02, 04.03, and 04.08.

⁴ Annual Book of ASTM Standards, Vol 04.08.

⁵ Annual Book of ASTM Standards, Vol 09.01.

⁶ Annual Book of ASTM Standards, Vol 14.02.

5.5 The liquid limit of a soil containing substantial amounts of organic matter decreases dramatically when the soil is oven-dried before testing. Comparison of the liquid limit of a sample before and after oven-drying can therefore be used as a qualitative measure of organic matter content of soil.

6. Apparatus

6.1 **Liquid Limit Device**—A mechanical device consisting of a brass cup suspended from a carriage designed to control the drop onto a hard rubber base. A drawing showing the essential features of the device and the critical dimensions is given in Fig. 1. The design of the device may vary provided the essential functions are preserved. The device may be operated either by a hand crank or by an electric motor.

6.1.1 **Base**—The base shall be hard rubber having a Durometer hardness of 80 to 90, and a resilience such that a 6-mm ($\frac{1}{16}$ -in.) diameter polished steel ball, when dropped from a height of 25 cm (9.84 in.) will have an average rebound of at least 80 % but no more than 90 %. The tests shall be conducted on the finished base with feet attached.

6.1.2 **Feet**—The base shall be supported by rubber feet designed to provide isolation of the base from the work surface and having an A Durometer hardness no greater than 40 as measured on the finished feet attached to the base.

6.1.3 **Cup**—The cup shall be brass and have a weight, including cup hanger, of 185 to 215 g.

6.1.4 **Cam**—The cam shall raise the cup smoothly and continuously to its maximum height, over a distance of at

least 180° of cam rotation. The preferred cam motion is a uniformly accelerated lift curve. The design of the cam and follower combination shall be such that there is no upward or downward velocity of the cup when the cam follower leaves the cam.

NOTE 3—The cam and follower design in Fig. 1 is for uniformly accelerated (parabolic) motion after contact and assures that the cup has no velocity at drop off. Other cam designs also provide this feature and may be used. However, if the cam-follower lift pattern is not known, zero velocity at drop off can be assured by carefully filing or machining the cam and follower so that the cup height remains constant over the last 20 to 45° of cam rotation.

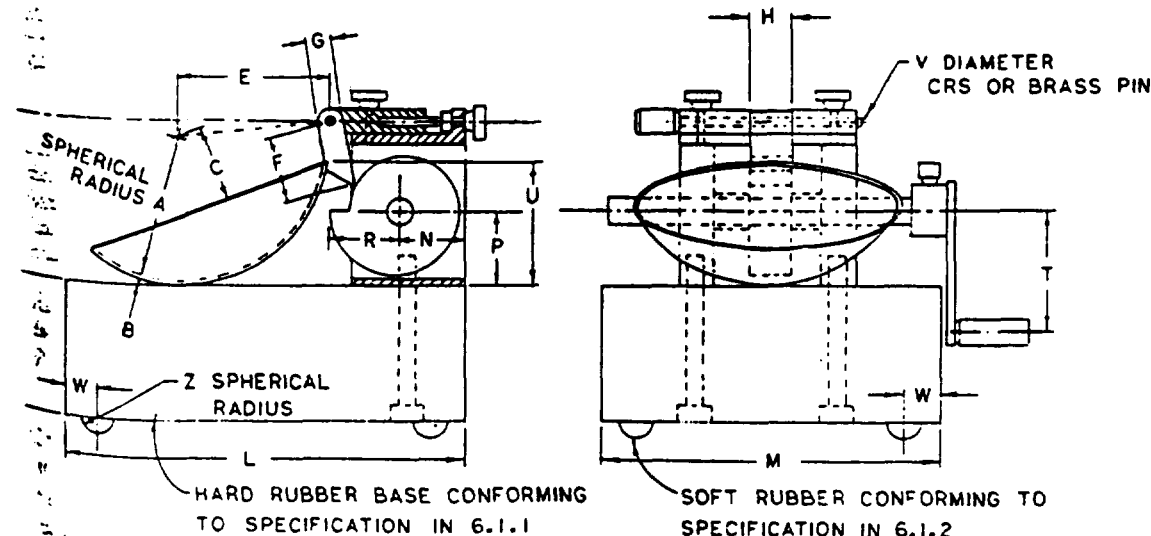
6.1.5 **Carriage**—The cup carriage shall be constructed in a way that allows convenient but secure adjustment of the height of drop of the cup to 10 mm (0.394 in.). The cup hanger shall be attached to the carriage by means of a pin which allows removal of the cup and cup hanger for cleaning and inspection.

6.1.6 **Optional Motor Drive**—As an alternative to the hand crank shown in Fig. 1, the device may be equipped with a motor to turn the cam. Such a motor must turn the cam at 2 ± 0.1 revolutions per second and must be isolated from the rest of the device by rubber mounts or in some other way that prevents vibration from the motor being transmitted to the rest of the apparatus. It must be equipped with an ON-OFF switch and a means of conveniently positioning the cam for height of drop adjustments. The results obtained using a motor-driven device must not differ from those obtained using a manually operated device.

DIMENSIONS

LETTER	A ^a	B ^a	C ^a	E ^a	F	G	H	J ^a	K ^a	L ^a	M ^a
MM	54	2	27	56	32	10	16	60	50	150	125
	± 0.5	± 0.1	± 0.5	± 2.0				± 1.0	± 2.0	± 2.0	± 2.0
LETTER	N	P	R	T	U ^a	V	W	Z			
MM	24	28	24	45	47	3.8	13	6.5			
					± 1.0						

ESSENTIAL DIMENSIONS



CAM ANGLE DEGREES	CAM RADIUS
0	0.742 R
30	0.753 R
60	0.764 R
90	0.773 R
120	0.784 R
150	0.796 R
180	0.818 R
210	0.854 R
240	0.901 R
270	0.945 R
300	0.974 R
330	0.995 R
360	1.000 R

FIG. 1 Hand-Operated Liquid Limit Device

000027

DIMENSIONS

LETTER	A ^Δ	B ^Δ	C ^Δ	D ^Δ	E ^Δ	F ^Δ
MM	2 ± 0.1	11 ± 0.2	40 ± 0.5	8 ± 0.1	50 ± 0.5	2 ± 0.1
LETTER	G	H	J	K ^Δ	L ^Δ	N
MM	10 MINIMUM	13	60	10 ± 0.05	60 DEG ± 1 DEG	20

^Δ ESSENTIAL DIMENSIONS

[□] BACK AT LEAST 15 MM FROM TIP

NOTE: DIMENSION A SHOULD BE 1.9–2.0 AND DIMENSION D SHOULD BE 8.0–8.1 WHEN NEW TO ALLOW FOR ADEQUATE SERVICE LIFE

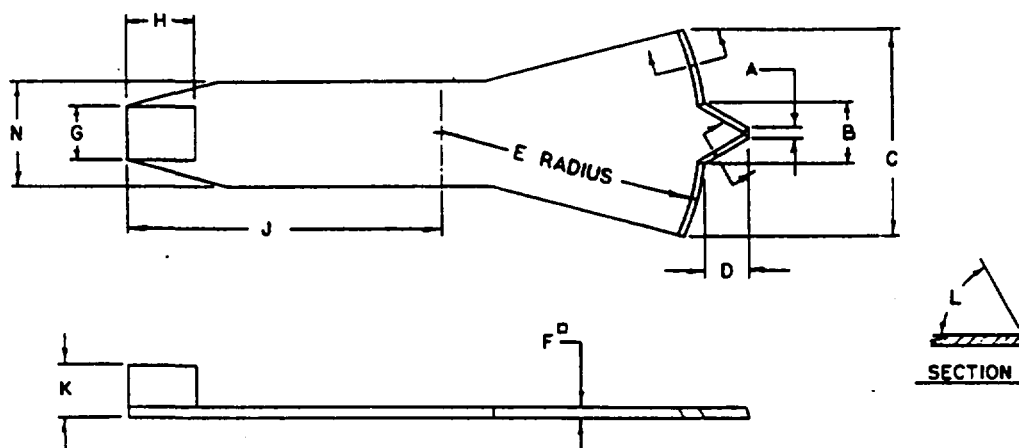
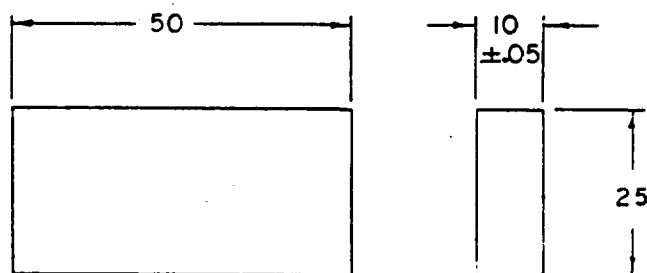


FIG. 2 Grooving Tool (Optional Height-of-Drop Gage Attached)

6.2 *Flat Grooving Tool*—A grooving tool having dimensions shown in Fig. 2. The tool shall be made of plastic or noncorroding metal. The design of the tool may vary as long as the essential dimensions are maintained. The tool may, but need not, incorporate the gage for adjusting the height of drop of the liquid limit device.

6.3 *Gage*—A metal gage block for adjusting the height of drop of the cup, having the dimensions shown in Fig. 3. The design of the tool may vary provided the gage will rest securely on the base without being susceptible to rocking, and the edge which contacts the cup during adjustment is straight, at least 10 mm (3/8 in.) wide, and without bevel or radius.



DIMENSIONS IN MILLIMETRES

FIG. 3 Height of Drop Gage

000028

6.4 *Containers*—Small corrosion-resistant containers with snug-fitting lids for water content specimens. Aluminum or stainless steel cans 2.5 cm (1 in.) high by 5 cm (2 in.) diameter are appropriate.

6.5 *Balance*—A balance readable to at least 0.01 g having an accuracy of 0.03 g within three standard deviations within the range of use. Within any 15-g range, difference between readings shall be accurate within 0.01 g (Notes 4 and 5).

NOTE 4—See Methods E 898 and E 319 for an explanation of relating to balance performance.

NOTE 5—For frequent use, a top-loading type balance with automatic load indication, readable to 0.01 g, and having an imprecision (standard deviation) of 0.003 or better is most suitable method. However, nonautomatic indicating equal-arm analytical balances and some small equal arm top pan balances having readability and sensitivities of 0.002 g or better provide the required accuracy used with a weight set of ASTM Class 4 (National Bureau of Standards Class P) or better. Ordinary commercial and classroom type balances such as beam balances are not suitable for this method.

6.6 *Storage Container*—A container in which to store prepared soil specimen that will not contaminate the specimen in any way, and which prevents moisture loss. Porcelain, glass, or plastic dish about 11.4 cm (4 1/2 in.) diameter and a plastic bag large enough to enclose the dish and be folded over is adequate.

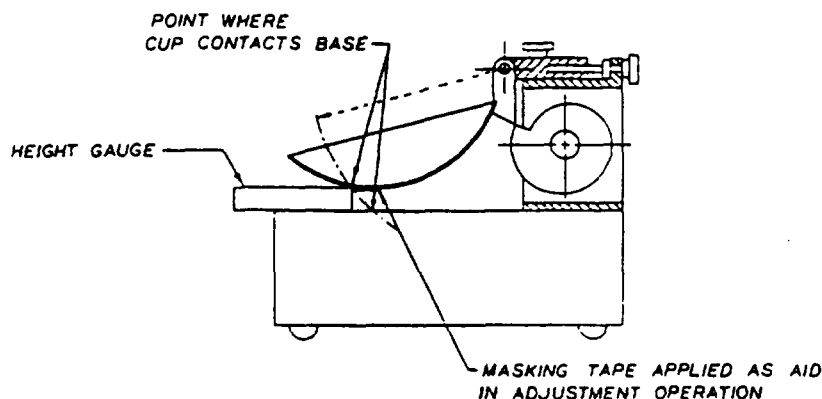


FIG. 4 Calibration for Height of Drop

6.7 *Ground Glass Plate*—A ground glass plate at least 30 cm (12 in.) square by 1 cm ($\frac{3}{8}$ in.) thick for mixing soil and rolling plastic limit threads.

6.8 *Spatula*—A spatula or pill knife having a blade about 2 cm ($\frac{3}{4}$ in.) wide by about 10 cm (4 in.) long. In addition, a spatula having a blade about 2.5 cm (1 in.) wide and 15 cm (6 in.) long has been found useful for initial mixing of samples.

6.9 *Sieve*—A 20.3 cm (8 in.) diameter, 425- μ m (No. 40) sieve conforming to the requirements of Specification E 11 and having a rim at least 5 cm (2 in.) above the mesh. A 75- μ m (No. 10) sieve meeting the same requirements may also be needed.

6.10 *Wash Bottle*, or similar container for adding controlled amounts of water to soil and washing fines from coarse particles.

6.11 *Drying Oven*—A thermostatically controlled oven, preferably of the forced-draft type, capable of continuously maintaining a temperature of $110 \pm 5^\circ\text{C}$ throughout the drying chamber. The oven shall be equipped with a thermometer of suitable range and accuracy for monitoring oven temperature.

6.12 *Washing Pan*—A round, flat-bottomed pan at least 15 cm (3 in.) deep, slightly larger at the bottom than a 23-cm (8-in.) diameter sieve.

6.13 *Rod* (optional)—A metal or plastic rod or tube 3.2 mm ($\frac{1}{8}$ in.) in diameter and about 10 cm (4 in.) long for rolling the size of plastic limit threads.

7. Materials

7.1 A supply of distilled or demineralized water.

8. Sampling

8.1 Samples may be taken from any location that satisfies testing needs. However, Methods C 702, Practice D 75, and recommended Practice D 420 should be used as guides for selecting and preserving samples from various types of sampling operations. Samples which will be prepared using the wet preparation procedure, 10.1, must be kept at their natural water content prior to preparation.

8.2 Where sampling operations have preserved the natural stratification of a sample, the various strata must be kept separated and tests performed on the particular stratum of interest with as little contamination as possible from other strata.

8.3 Where a mixture of materials will be used in construction, combine the various components in such proportions that the resultant sample represents the actual construction case.

8.3 Where data from this test method are to be used for correlation with other laboratory or field test data, use the same material as used for these tests where possible.

8.4 Obtain a representative portion from the total sample sufficient to provide 150 to 200 g of material passing the 425- μ m (No. 40) sieve. Free flowing samples may be reduced by the methods of quartering or splitting. Cohesive samples shall be mixed thoroughly in a pan with a spatula, or scoop and a representative portion scooped from the total mass by making one or more sweeps with a scoop through the mixed mass.

9. Calibration of Apparatus

9.1 Inspection of Wear:

9.1.1 *Liquid Limit Device*—Determine that the liquid limit device is clean and in good working order. The following specific points should be checked:

9.1.1.1 *Wear of Base*—The spot on the base where the cup makes contact should be worn no greater than 10 mm ($\frac{3}{8}$ in.) in diameter. If the wear spot is greater than this, the base can be machined to remove the worn spot provided the resurfacing does not make the base thinner than specified in 6.1 and the other dimensional relationships are maintained.

9.1.1.2 *Wear of Cup*—The cup must be replaced when the grooving tool has worn a depression in the cup 0.1 mm (0.004 in.) deep or when the edge of the cup has been reduced to half its original thickness. Verify that the cup is firmly attached to the cup hanger.

9.1.1.3 *Wear of Cup Hanger*—Verify that the cup hanger pivot does not bind and is not worn to an extent that allows more than 3-mm ($\frac{1}{8}$ in.) side-to-side movement of the lowest point on the rim.

9.1.1.4 *Wear of Cam*—The cam shall not be worn to an extent that the cup drops before the cup hanger (cam follower) loses contact with the cam.

9.1.2 *Grooving Tools*—Inspect grooving tools for wear on a frequent and regular basis. The rapidity of wear depends on the material from which the tool is made and the types of soils being tested. Sandy soils cause rapid wear of grooving tools; therefore, when testing these materials, tools should be inspected more frequently than for other soils. Any tool with a tip width greater than 2.1 mm must not be used. The depth

of the tip of the grooving tool must be 7.9 to 8.1 mm.

NOTE 6—The width of the tip of grooving tools is conveniently checked using a pocket-sized measuring magnifier equipped with a millimetre scale. Magnifiers of this type are available from most laboratory supply companies. The depth of the tip of grooving tools can be checked using the depth measuring feature of vernier calipers.

9.2 *Adjustment of Height of Drop*—Adjust the height of drop of the cup so that the point on the cup that comes in contact with the base rises to a height of 10 ± 0.2 mm. See Fig. 4 for proper location of the gage relative to the cup during adjustment.

NOTE 7—A convenient procedure for adjusting the height of drop is as follows: place a piece of masking tape across the outside bottom of the cup parallel with the axis of the cup hanger pivot. The edge of the tape away from the cup hanger should bisect the spot on the cup that contacts the base. For new cups, placing a piece of carbon paper on the base and allowing the cup to drop several times will mark the contact spot. Attach the cup to the device and turn the crank until the cup is raised to its maximum height. Slide the height gage under the cup from the front, and observe whether the gage contacts the cup or the tape. See Fig. 4. If the tape and cup are both contacted, the height of drop is approximately correct. If not, adjust the cup until simultaneous contact is made. Check adjustment by turning the crank at 2 revolutions per second while holding the gage in position against the tape and cup. If a ringing or clicking sound is heard without the cup rising from the gage, the adjustment is correct. If no ringing is heard or if the cup rises from the gage, readjust the height of drop. If the cup rocks on the gage during this checking operation, the cam follower pivot is excessively worn and the worn parts should be replaced. Always remove tape after completion of adjustment operation.

MULTIPOINT LIQUID LIMIT—PROCEDURES A AND B

10. Preparation of Test Specimens

10.1 *Wet Preparation*—Except where the dry method of specimen preparation is specified (10.2), prepare specimens for test as described in the following sections.

10.1.1 *Samples Passing the 425- μ m (No. 40) Sieve*—When by visual and manual procedures it is determined that the sample has little or no material retained on a 425- μ m (No. 40) sieve, prepare a specimen of 150 to 200 g by mixing thoroughly with distilled or demineralized water on the glass plate using the spatula. If desired, soak soil in a storage dish with small amount of water to soften the soil before the start of mixing. Adjust the water content of the soil to bring it to a consistency that would require 25 to 35 blows of the liquid limit device to close the groove (Note 8). If, during mixing, a small percentage of material is encountered that would be retained on a 425- μ m (No. 40) sieve, remove these particles by hand, if possible. If it is impractical to remove the coarser material by hand, remove small percentages (less than about 15 %) of coarser material by working the specimen through a 425- μ m (No. 40) sieve using a piece of rubber sheeting, rubber stopper, or other convenient device provided the operation does not distort the sieve or degrade material that would be retained if the washing method described in 10.1.2 were used. If larger percentages of coarse material are encountered during mixing, or it is considered impractical to remove the coarser material by the methods just described, wash the sample as described in 10.1.2. When the coarse particles found during mixing are concretions, shells, or other fragile particles, do not crush these particles to make them pass a 425- μ m (No. 40) sieve, but remove by hand or by washing. Place the mixed soil in the storage dish, cover to

prevent loss of moisture, and allow to stand for at least 16 h (overnight). After the standing period and immediately before starting the test, thoroughly remix the soil.

NOTE 8—The time taken to adequately mix a soil will vary greatly, depending on the plasticity and initial water content. Initial mixing times of more than 30 min may be needed for stiff, fat clays.

10.1.2 *Samples Containing Material Retained on a 425- μ m (No. 40) Sieve*

10.1.2.1 Select a sufficient quantity of soil at natural water content to provide 150 to 200 g of material passing the 425- μ m (No. 40) sieve. Place in a pan or dish and add sufficient water to cover the soil. Allow to soak until all lumps have softened and the fines no longer adhere to the surfaces of the coarse particles (Note 9).

NOTE 9—In some cases, the cations of salts present in tap water will exchange with the natural cations in the soil and significantly alter the test results should tap water be used in the soaking and washing operations. Unless it is known that such cations are not present in the tap water, distilled or demineralized water should be used. As a general rule, water containing more than 100 mg/L of dissolved solids should not be used for washing operations.

10.1.2.2 When the sample contains a large percentage of material retained on the 425- μ m (No. 40) sieve, perform the following washing operation in increments, washing no more than 0.5 kg (1 lb) of material at one time. Place the 425- μ m (No. 40) sieve in the bottom of the clean pan. Pour the soil-water mixture onto the sieve. If gravel or coarse sand particles are present, rinse as many of these as possible with small quantities of water from a wash bottle, and discard. Alternatively, pour the soil-water mixture over a 2-mm (No. 10) sieve nested atop the 425- μ m (No. 40) sieve, rinse the fine material through and remove the 2-mm (No. 10) sieve. After washing and removing as much of the coarser material as possible, add sufficient water to the pan to bring the level to about 13 mm ($\frac{1}{2}$ in.) above the surface of the 425- μ m (No. 40) sieve. Agitate the slurry by stirring with the fingers while raising and lowering the sieve in the pan and swirling the suspension so that fine material is washed from the coarse particles. Disaggregate fine soil lumps that have not slaked by gently rubbing them over the sieve with the fingers. Complete the washing operation by raising the sieve above the water surface and rinsing the material retained with a small amount of clean water. Discard material retained on the 425- μ m (No. 40) sieve.

10.1.2.3 Reduce the water content of the material passing the 425- μ m (No. 40) sieve until it approaches the liquid limit. Reduction of water content may be accomplished by one or a combination of the following methods: (a) exposure to air currents at ordinary room temperature, (b) exposure to warm air currents from a source such as an electric hair dryer, (c) filtering in a Büchner funnel or using filter cake, (d) decanting clear water from surface of suspension, or (e) draining in a colander or plaster of paris dish lined with retentivity, high wet-strength filter paper.⁷ If a plaster of paris dish is used, take care that the dish never becomes sufficiently saturated that it fails to actively absorb water from its surface. Thoroughly dry dishes between uses. During evaporation and cooling, stir the sample often enough to pre-

⁷ S and S 595 filter paper available in 32-cm circles, has proven satisfactory.

overdrying of the fringes and soil pinnacles on the surface of the mixture. For soil samples containing soluble salts, use a method of water reduction such as *a* or *b* that will not eliminate the soluble salts from the test specimen.

10.1.2.4 Thoroughly mix the material passing the 425- μ m (No. 40) sieve on the glass plate using the spatula. Adjust the water content of the mixture, if necessary, by adding small increments of distilled or demineralized water or by allowing the mixture to dry at room temperature while mixing on the glass plate. The soil should be at a water content that will result in closure of the groove in 25 to 35 blows. Return the mixed soil to the mixing dish, cover to prevent loss of moisture, and allow to stand for at least 16 h. After the standing period, and immediately before starting the test, remix the soil thoroughly.

10.2 Dry Preparation:

10.2.1 Select sufficient soil to provide 150 to 200 g of material passing the 425- μ m (No. 40) sieve after processing. Dry the sample at room temperature or in an oven at a temperature not exceeding 60°C until the soil clods will pulverize readily. Disaggregation is expedited if the sample is not allowed to completely dry. However, the soil should have a dry appearance when pulverized. Pulverize the sample in a mortar with a rubber tipped pestle or in some other way that does not cause breakdown of individual grains. When the coarse particles found during pulverization are concretions, lumps, or other fragile particles, do not crush these particles to make them pass a 425- μ m (No. 40) sieve, but remove by hand or other suitable means, such as washing.

10.2.2 Separate the sample on a 425- μ m (No. 40) sieve, shaking the sieve by hand to assure thorough separation of the finer fraction. Return the material retained on the 425- μ m (No. 40) sieve to the pulverizing apparatus and repeat the pulverizing and sieving operations as many times as necessary to assure that all finer material has been

disaggregated and material retained on the 425- μ m (No. 40) sieve consists only of individual sand or gravel grains.

10.2.3 Place material remaining on the 425- μ m (No. 40) sieve after the final pulverizing operations in a dish and soak in a small amount of water. Stir the soil water mixture and pour over the 425- μ m (No. 40) sieve, catching the water and any suspended fines in the washing pan. Pour this suspension into a dish containing the dry soil previously sieved through the 425- μ m (No. 40) sieve. Discard material retained on the 425- μ m (No. 40) sieve.

10.2.4 Adjust the water content as necessary by drying as described in 10.1.2.3 or by mixing on the glass plate, using the spatula while adding increments of distilled or demineralized water, until the soil is at a water content that will result in closure of the groove in 25 to 35 blows.

10.2.5 Put soil in the storage dish, cover to prevent loss of moisture and allow to stand for at least 16 h. After the standing period, and immediately before starting the test, thoroughly remix the soil (Note 8).

11. Procedure

11.1 Place a portion of the prepared soil in the cup of the liquid limit device at the point where the cup rests on the base, squeeze it down, and spread it into the cup to a depth of about 10 mm at its deepest point, tapering to form an approximately horizontal surface. Take care to eliminate air bubbles from the soil pat but form the pat with as few strokes as possible. Heap the unused soil on the glass plate and cover with the inverted storage dish or a wet towel.

11.2 Form a groove in the soil pat by drawing the tool, beveled edge forward, through the soil on a line joining the highest point to the lowest point on the rim of the cup. When cutting the groove, hold the grooving tool against the surface of the cup and draw in an arc, maintaining the tool perpendicular to the surface of the cup throughout its

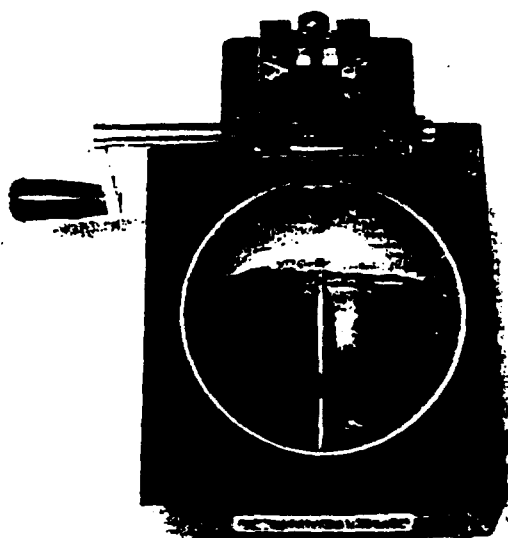


FIG. 5 Grooved Soil Pat in Liquid Limit Device

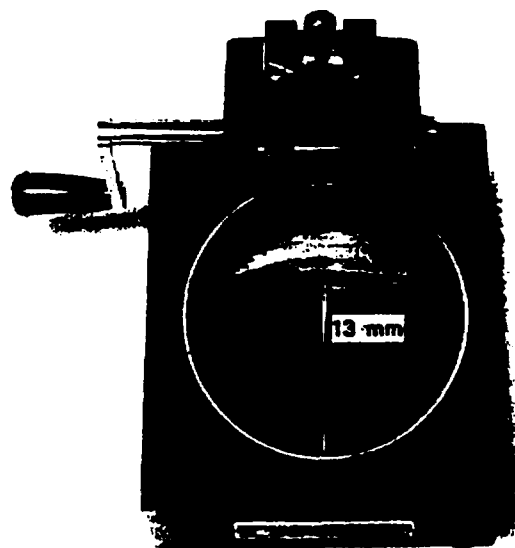


FIG. 6 Soil Pat After Groove Has Closed

movement. See Fig. 5. In soils where a groove cannot be made in one stroke without tearing the soil, cut the groove with several strokes of the grooving tool. Alternatively, cut the groove to slightly less than required dimensions with a spatula and use the grooving tool to bring the groove to final dimensions. Exercise extreme care to prevent sliding the soil pat relative to the surface of the cup.

11.3 Verify that no crumbs of soil are present on the base or the underside of the cup. Lift and drop the cup by turning the crank at a rate of 1.9 to 2.1 drops per second until the two halves of the soil pat come in contact at the bottom of the groove along a distance of 13 mm ($\frac{1}{2}$ in.). See Fig. 6.

NOTE 10—Use the end of the grooving tool, Fig. 2, or a scale to verify that the groove has closed 13 mm ($\frac{1}{2}$ in.).

11.4 Verify that an air bubble has not caused premature closing of the groove by observing that both sides of the groove have flowed together with approximately the same shape. If a bubble has caused premature closing of the groove, reform the soil in the cup, adding a small amount of soil to make up for that lost in the grooving operation and repeat 11.1 to 11.3. If the soil slides on the surface of the cup, repeat 11.1 through 11.3 at a higher water content. If, after several trials at successively higher water contents, the soil pat continues to slide in the cup or if the number of blows required to close the groove is always less than 25, record that the liquid limit could not be determined, and report the soil as nonplastic without performing the plastic limit test.

11.5 Record the number of drops, N , required to close the groove. Remove a slice of soil approximately the width of the spatula, extending from edge to edge of the soil cake at right angles to the groove and including that portion of the groove in which the soil flowed together, place in a weighed container, and cover.

11.6 Return the soil remaining in the cup to the glass plate. Wash and dry the cup and grooving tool and reattach

the cup to the carriage in preparation for the next trial.

11.7 Remix the entire soil specimen on the glass plate, adding distilled water to increase the water content of the soil and decrease the number of blows required to close the groove. Repeat 11.1 through 11.6 for at least two additional trials producing successively lower numbers of blows to close the groove. One of the trials shall be for a closure requiring 25 to 35 blows, one for closure between 20 and 30 blows, and one trial for a closure requiring 15 to 25 blows.

11.8 Determine the water content, W , of the soil specimen from each trial in accordance with Method D 223. Make all weighings on the same balance. Initial weighing should be performed immediately after completion of the test. If the test is to be interrupted for more than about 15 min, the specimens already obtained should be weighed at the time of the interruption.

12. Calculations

12.1 Plot the relationship between the water content, W , and the corresponding number of drops, N , of the cup on a semilogarithmic graph with the water content as ordinate on the arithmetical scale, and the number of drops as abscissa on the logarithmic scale. Draw the best straight line through the three or more plotted points.

12.2 Take the water content corresponding to the section of the line with the 25-drop abscissa as the liquid limit of the soil. Computational methods may be substituted for the graphical method for fitting a straight line to the data and determining the liquid limit.

ONE-POINT LIQUID LIMIT—PROCEDURES C AND D

13. Preparation of Test Specimens

13.1 Prepare the specimen in the same manner as described in Section 10, except that at mixing, adjust the water content to a consistency requiring 20 to 30 drops

TABLE 1 Factors for Obtaining Liquid Limit from Water Content and Number of Drops Causing Closure of Groove

N (Number of Drops)	K (Factor for Liquid Limit)
20	0.974
21	0.979
22	0.985
23	0.990
24	0.995
25	1.000
26	1.005
27	1.009
28	1.014
29	1.018
30	1.022

liquid limit cup to close the groove.

14. Procedure

14.1 Proceed as described in 11.1 through 11.5 except that the number of blows required to close the groove shall be 20 to 30. If less than 20 or more than 30 blows are required, adjust the water content of the soil and repeat the procedure.

14.2 Immediately after removing a water content specimen as described in 11.5, reform the soil in the cup, adding a small amount of soil to make up for that lost in the proofing and water content sampling operations. Repeat 11.2 through 11.5, and, if the second closing of the groove requires the same number of drops or no more than two drops difference, secure another water content specimen. Otherwise, remix the entire specimen and repeat.

NOTE 11—Excessive drying or inadequate mixing will cause the number of blows to vary.

14.3 Determine water contents of specimens as described in 11.8.

15. Calculations

15.1 Determine the liquid limit for each water content specimen using one of the following equations:

$$LL = W_N \left(\frac{N}{25} \right)^{0.121} \quad \text{or} \\ LL = K(W_N)$$

where:
 N = the number of blows causing closure of the groove at water content,
 W_N = water content, and
 K = a factor given in Table 1.

The liquid limit is the average of the two trial liquid limit

15.2 If the difference between the two trial liquid limit is greater than one percentage point, repeat the test.

PLASTIC LIMIT

16. Preparation of Test Specimen

16.1 Select a 20-g portion of soil from the material prepared for the liquid limit test, either after the second rolling before the test, or from the soil remaining after completion of the test. Reduce the water content of the soil to a consistency at which it can be rolled without sticking to the hands by spreading and mixing continuously on the glass plate. The drying process may be accelerated by exposing the

soil to the air current from an electric fan, or by blotting with paper that does not add any fiber to the soil, such as hard surface paper toweling or high wet-strength filter paper.

17. Procedure

17.1 From the 20-g mass, select a portion of 1.5 to 2.0 g. Form the test specimen into an ellipsoidal mass. Roll this mass between the palm or fingers and the ground-glass plate with just sufficient pressure to roll the mass into a thread of uniform diameter throughout its length (Note 12). The thread shall be further deformed on each stroke so that its diameter is continuously reduced and its length extended until the diameter reaches 3.2 ± 0.5 mm ($0.125 \pm .020$ in.), taking no more than 2 min (Note 13). The amount of hand or finger pressure required will vary greatly, according to the soil. Fragile soils of low plasticity are best rolled under the outer edge of the palm or at the base of the thumb.

NOTE 12—A normal rate of rolling for most soils should be 80 to 90 strokes per minute, counting a stroke as one complete motion of the hand forward and back to the starting position. This rate of rolling may have to be decreased for very fragile soils.

NOTE 13—A 3.2-mm ($\frac{1}{8}$ -in.) diameter rod or tube is useful for frequent comparison with the soil thread to ascertain when the thread has reached the proper diameter, especially for inexperienced operators.

17.1.1 When the diameter of the thread becomes 3.2 mm, break the thread into several pieces. Squeeze the pieces together, knead between the thumb and first finger of each hand, reform into an ellipsoidal mass, and reroll. Continue this alternate rolling to a thread 3.2 mm in diameter, gathering together, kneading and rerolling, until the thread crumbles under the pressure required for rolling and the soil can no longer be rolled into a 3.2-mm diameter thread (See Fig. 7). It has no significance if the thread breaks into threads of shorter length. Roll each of these shorter threads to 3.2 mm in diameter. The only requirement for continuing the test is that they are able to be reformed into an ellipsoidal mass and rolled out again. The operator shall at no time attempt to produce failure at exactly 3.2 mm diameter by allowing the thread to reach 3.2 mm, then reducing the rate of rolling or the hand pressure, or both, while continuing the rolling without further deformation until the thread falls apart. It is permissible, however, to reduce the total amount of deformation for feebly plastic soils by making the initial diameter of the ellipsoidal mass nearer to the required 3.2-mm final diameter. If crumbling occurs when the thread has a diameter greater than 3.2 mm, this shall be considered a satisfactory end point, provided the soil has been previously rolled into a thread 3.2 mm in diameter. Crumbling of the thread will manifest itself differently with the various types of soil. Some soils fall apart in numerous small aggregations of particles, others may form an outside tubular layer that starts splitting at both ends. The splitting progresses toward the middle, and finally, the thread falls apart in many small platy particles. Fat clay soils require much pressure to deform the thread, particularly as they approach the plastic limit. With these soils, the thread breaks into a series of barrel-shaped segments about 3.2 to 9.5 mm ($\frac{1}{8}$ to $\frac{3}{8}$ in.) in length.

17.2 Gather the portions of the crumbled thread together and place in a weighed container. Immediately cover the container.

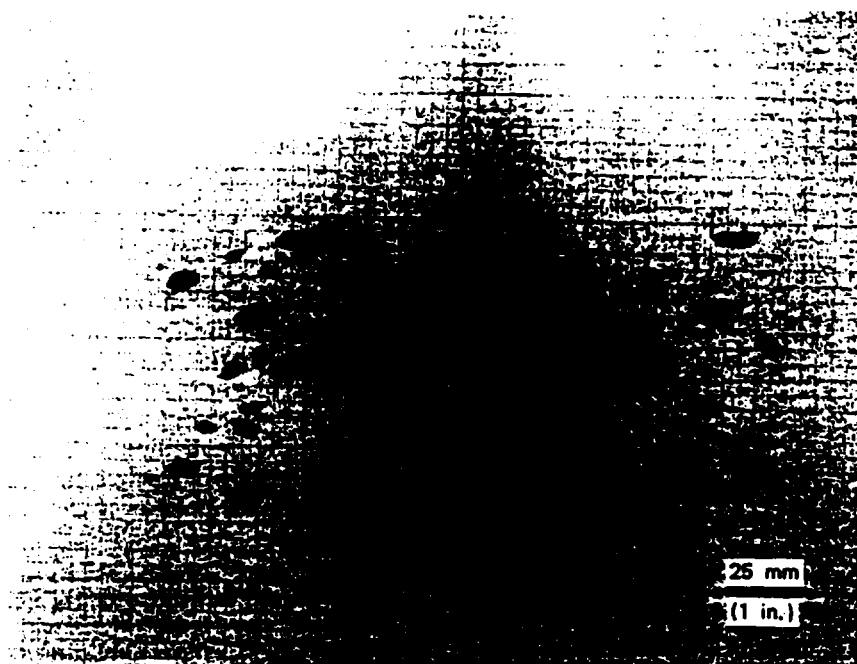


FIG. 7 Lean Clay Soil at the Plastic Limit

17.3 Select another 1.5 to 2.0 g portion of soil from the original 20-g specimen and repeat the operations described in 17.1 and 17.2 until the container has at least 6 g of soil.

17.4 Repeat 17.1 through 17.3 to make another container holding at least 6 g of soil. Determine the water content, in percent, of the soil contained in the containers in accordance with Method D 2216. Make all weighings on the same balance.

NOTE 14—The intent of performing two plastic limit trials is to verify the consistency of the test results. It is acceptable practice to perform only one plastic limit trial when the consistency in the test results can be confirmed by other means.

18. Calculations

18.1 Compute the average of the two water contents. If the difference between the two water contents is greater than two percentage points, repeat the test. The plastic limit is the average of the two water contents.

PLASTICITY INDEX

19. Calculations

19.1 Calculate the plasticity index as follows:

$$PI = LL - PL$$

where:

LL = the liquid limit,

PL = the plastic limit.

Both LL and PL are whole numbers. If either the liquid limit or plastic limit could not be determined, or if the plastic limit is equal to or greater than the liquid limit, report the soil as nonplastic, NP.

20. Report

20.1 Report the following information:

20.1.1 Sample identifying information,

20.1.2 Any special specimen selection process used, such as removal of sand lenses from undisturbed sample,

20.1.3 Report sample as airdried if the sample was airdried before or during preparation,

20.1.4 Liquid limit, plastic limit, and plasticity index to the nearest whole number and omitting the percent designation. If the liquid limit or plastic limit tests could not be performed, or if the plastic limit is equal to or greater than the liquid limit, report the soil as nonplastic, NP,

20.1.5 An estimate of the percentage of sample retained on the 425-μm (No. 40) sieve, and

20.1.6 Procedure by which liquid limit was performed, if it differs from the multipoint method.

21. Precision and Bias

21.1 No interlaboratory testing program has as yet been conducted using this test method to determine multipoint laboratory precision.

21.2 The within laboratory precision of the results of tests performed by different operators at one laboratory on soils using Procedure A for the liquid limit is shown in Table 2.

TABLE 2 Within Laboratory Precision for Liquid Limit

	Average Value, %	Standard Deviation, %
Soil A:		
PL	21.9	1.07
LL	27.9	1.07
Soil B:		
PL	20.1	1.21
LL	32.6	0.98

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This standard is subject to revision at any time by the responsible technical committee and must be reviewed every five years and if not revised, either reapproved or withdrawn. Your comments are invited either for revision of this standard or for additional standards and should be addressed to ASTM Headquarters. Your comments will receive careful consideration at a meeting of the responsible technical committee, which you may attend. If you feel that your comments have not received a fair hearing you should make your views known to the ASTM Committee on Standards, 1916 Race St., Philadelphia, PA 19103.



Standard Method for Particle-Size Analysis of Soils¹

This standard is issued under the fixed designation D 422; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ϵ) indicates an editorial change since the last revision or reapproval.

^{ε1} NOTE—Section 2 was added editorially and subsequent sections renumbered in July 1984.

1. Scope

1.1 This method covers the quantitative determination of the distribution of particle sizes in soils. The distribution of particle sizes larger than 75 μm (retained on the No. 200 sieve) is determined by sieving, while the distribution of particle sizes smaller than 75 μm is determined by a sedimentation process, using a hydrometer to secure the necessary data (Notes 1 and 2).

NOTE 1—Separation may be made on the No. 4 (4.75-mm), No. 40 (425- μm), or No. 200 (75- μm) sieve instead of the No. 10. For whatever sieve used, the size shall be indicated in the report.

NOTE 2—Two types of dispersion devices are provided: (1) a high-speed mechanical stirrer, and (2) air dispersion. Extensive investigations indicate that air-dispersion devices produce a more positive dispersion of plastic soils below the 20- μm size and appreciably less degradation on all sizes when used with sandy soils. Because of the definite advantages favoring air dispersion, its use is recommended. The results from the two types of devices differ in magnitude, depending upon soil type, leading to marked differences in particle size distribution, especially for sizes finer than 20 μm .

2. Referenced Documents

2.1 ASTM Standards:

D 421 Practice for Dry Preparation of Soil Samples for Particle-Size Analysis and Determination of Soil Constants²

E 11 Specification for Wire-Cloth Sieves for Testing Purposes³

E 100 Specification for ASTM Hydrometers⁴

3. Apparatus

3.1 *Balances*—A balance sensitive to 0.01 g for weighing the material passing a No. 10 (2.00-mm) sieve, and a balance sensitive to 0.1 % of the mass of the sample to be weighed for weighing the material retained on a No. 10 sieve.

3.2 *Stirring Apparatus*—Either apparatus A or B may be used.

3.2.1 Apparatus A shall consist of a mechanically operated stirring device in which a suitably mounted electric motor turns a vertical shaft at a speed of not less than 10 000 rpm without load. The shaft shall be equipped with a replaceable stirring paddle made of metal, plastic, or hard rubber, as shown in Fig. 1. The shaft shall be of such length that the stirring paddle will operate not less than $\frac{3}{4}$ in. (19.0 mm) nor more than 1 $\frac{1}{2}$ in. (38.1 mm) above the bottom of the dispersion cup. A special dispersion cup conforming to either of the designs shown in Fig. 2 shall be provided to hold the sample while it is being dispersed.

3.2.2 Apparatus B shall consist of an air-jet dispersion cup⁵ (Note 3) conforming to the general details shown in Fig. 3 (Notes 4 and 5).

NOTE 3—The amount of air required by an air-jet dispersion cup is of the order of 2 ft³/min; some small air compressors are not capable of supplying sufficient air to operate a cup.

NOTE 4—Another air-type dispersion device, known as a dispersion tube, developed by Chu and Davidson at Iowa State College, has been shown to give results equivalent to those secured by the air-jet dispersion cups. When it is used, soaking of the sample can be done in the sedimentation cylinder, thus eliminating the need for transferring the slurry. When the air-dispersion tube is used, it shall be so indicated in the report.

NOTE 5—Water may condense in air lines when not in use. This water must be removed, either by using a water trap on the air line, or by blowing the water out of the line before using any of the dispersion purposes.

3.3 *Hydrometer*—An ASTM hydrometer, graduated to read in either specific gravity of the suspension or grams per litre of suspension, and conforming to the requirements for hydrometers 151H or 152H in Specifications E 100. Dimensions of both hydrometers are the same, the scale being the only item of difference.

3.4 *Sedimentation Cylinder*—A glass cylinder essentially 18 in. (457 mm) in height and 2 $\frac{1}{2}$ in. (63.5 mm) in diameter, and marked for a volume of 1000 mL. The inside diameter shall be such that the 1000-mL mark is 36 ± 2 cm from the bottom on the inside.

3.5 *Thermometer*—A thermometer accurate to 1°F (0.5°C).

3.6 *Sieves*—A series of sieves, of square-mesh woven-wire cloth, conforming to the requirements of Specification E 11. A full set of sieves includes the following (Note 6):

¹ This method is under the jurisdiction of ASTM Committee D-18 on Soil and Rock and is the direct responsibility of Subcommittee D18.03 on Texture, Plasticity, and Density Characteristics of Soils.

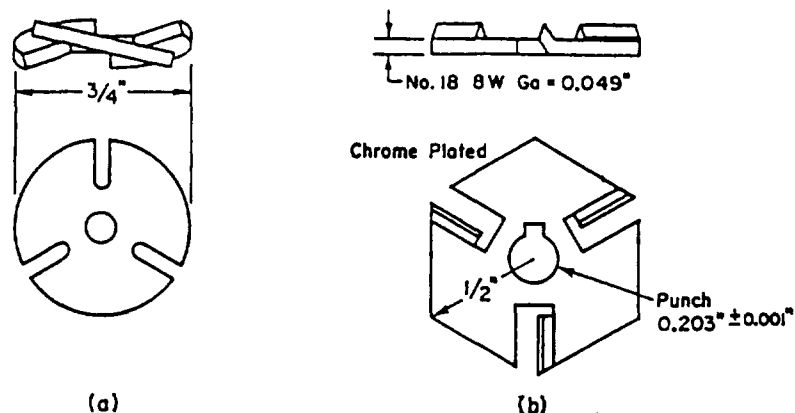
Current edition approved Nov. 21, 1963. Originally published 1935. Replaces D 422 - 62.

² Annual Book of ASTM Standards, Vol 04.08.

³ Annual Book of ASTM Standards, Vol 14.02.

⁴ Annual Book of ASTM Standards, Vol 14.03.

⁵ Detailed working drawings for this cup are available at a nominal cost from the American Society for Testing and Materials, 1916 Race St., Philadelphia, PA 19103. Order Adjunct No. 12-404220-00.



Metric Equivalents					
in.	0.001	0.049	0.203	1/2	3/4
mm	0.03	1.24	5.16	12.7	19.0

FIG. 1 Detail of Stirring Paddles

3-in. (75-mm)	No. 10 (2.00-mm)
2-in. (50-mm)	No. 20 (850-μm)
1 1/2-in. (37.5-mm)	No. 40 (425-μm)
1-in. (25.0-mm)	No. 60 (250-μm)
3/4-in. (19.0-mm)	No. 140 (106-μm)
1/2-in. (12.5-mm)	No. 200 (75-μm)
No. 4 (4.75-mm)	

NOTE 6—A set of sieves giving uniform spacing of points for the graph, as required in Section 17, may be used if desired. This set consists of the following sieves:

3-in. (75-mm)	No. 16 (1.18-mm)
1 1/2-in. (37.5-mm)	No. 30 (600-μm)
3/4-in. (19.0-mm)	No. 50 (300-μm)
1-in. (25.0-mm)	No. 100 (150-μm)
No. 4 (4.75-mm)	No. 200 (75-μm)
No. 8 (2.36-mm)	

3.7 *Water Bath or Constant-Temperature Room*—A water bath or constant-temperature room for maintaining the soil suspension at a constant temperature during the hydrometer analysis. A satisfactory water tank is an insulated tank that maintains the temperature of the suspension at a convenient constant temperature at or near 68°F (20°C). Such a device is illustrated in Fig. 4. In cases where the work is performed in a room at an automatically controlled constant temperature, the water bath is not necessary.

3.8 *Beaker*—A beaker of 250-mL capacity.

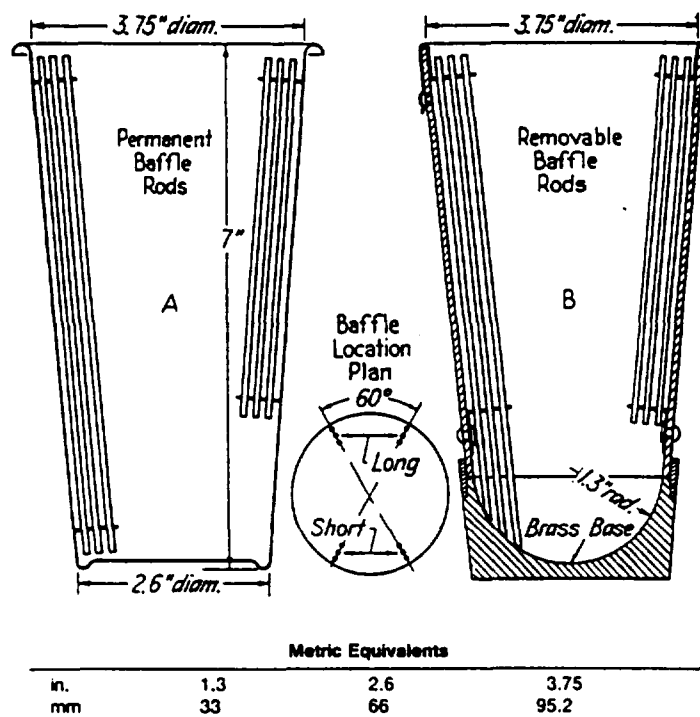
3.9 *Timing Device*—A watch or clock with a second hand.

4. Dispersing Agent

4.1 A solution of sodium hexametaphosphate (sometimes called sodium metaphosphate) shall be used in distilled or demineralized water, at the rate of 40 g of sodium hexametaphosphate/litre of solution (Note 7).

NOTE 7—Solutions of this salt, if acidic, slowly revert or hydrolyze back to the orthophosphate form with a resultant decrease in dispersive action. Solutions should be prepared frequently (at least once a month) or adjusted to pH of 8 or 9 by means of sodium carbonate. Bottles containing solutions should have the date of preparation marked on them.

4.2 All water used shall be either distilled or demineralized water. The water for a hydrometer test shall



Metric Equivalents			
in.	1.3	2.6	3.75
mm	33	66	95.2

FIG. 2 Dispersion Cups of Apparatus

be brought to the temperature that is expected to prevail during the hydrometer test. For example, if the sedimentation cylinder is to be placed in the water bath, the distilled or demineralized water to be used shall be brought to the temperature of the controlled water bath; or, if the sedimentation cylinder is used in a room with controlled temperature, the water for the test shall be at the temperature of the room. The basic temperature for the hydrometer test is 68°F (20°C). Small variations of temperature do not introduce differences that are of practical significance and do not prevent the use of corrections derived as prescribed.

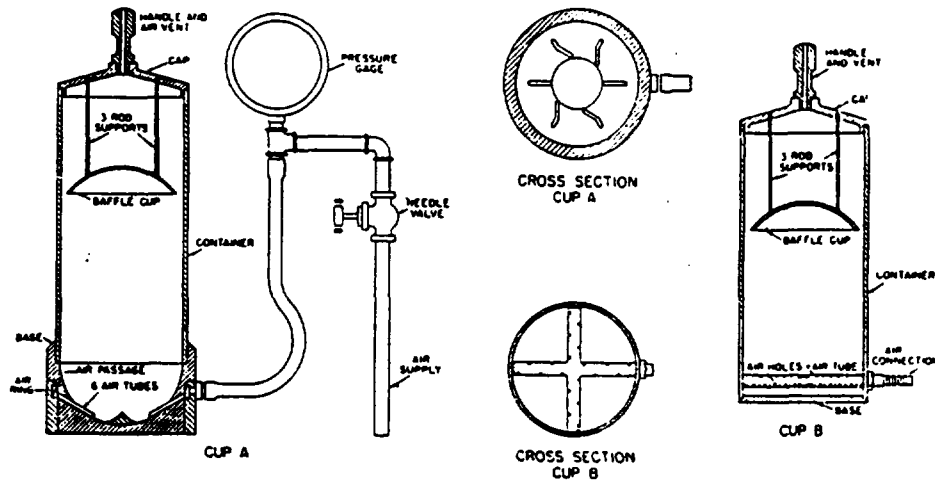


FIG. 3 Air-Jet Dispersion Cups of Apparatus B

5. Test Sample

5.1 Prepare the test sample for mechanical analysis as outlined in Practice D 421. During the preparation procedure the sample is divided into two portions. One portion contains only particles retained on the No. 10 (2.00-mm) sieve while the other portion contains only particles passing the No. 10 sieve. The mass of air-dried soil selected for purpose of tests, as prescribed in Practice D 421, shall be sufficient to yield quantities for mechanical analysis as follows:

5.1.1 The size of the portion retained on the No. 10 sieve shall depend on the maximum size of particle, according to the following schedule:

Nominal Diameter of Largest Particles, in. (mm)	Approximate Minimum Mass of Portion, g
3/8 (9.5)	500
1/4 (19.0)	1000
1 (25.4)	2000
1 1/2 (38.1)	3000
2 (50.8)	4000
3 (76.2)	5000

5.1.2 The size of the portion passing the No. 10 sieve shall be approximately 115 g for sandy soils and approximately 65 g for silt and clay soils.

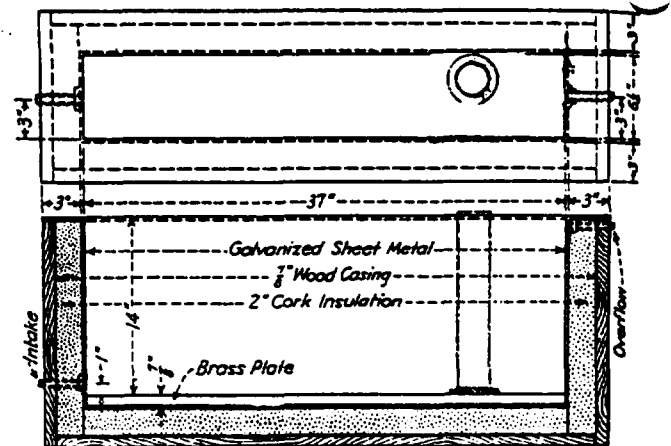
5.2 Provision is made in Section 5 of Practice D 421 for weighing of the air-dry soil selected for purpose of tests, the separation of the soil on the No. 10 sieve by dry-sieving and washing, and the weighing of the washed and dried fraction retained on the No. 10 sieve. From these two masses the percentages retained and passing the No. 10 sieve can be calculated in accordance with 12.1.

NOTE 8—A check on the mass values and the thoroughness of pulverization of the clods may be secured by weighing the portion passing the No. 10 sieve and adding this value to the mass of the washed and oven-dried portion retained on the No. 10 sieve.

SIEVE ANALYSIS OF PORTION RETAINED ON NO. 10 (2.00-mm) SIEVE

6. Procedure

6.1 Separate the portion retained on the No. 10 (2.00-mm) sieve into a series of fractions using the 3-in. (75-mm),



Metric Equivalents					
in.	1 1/2	1	3	6 1/4	14
mm	22.2	25.4	76.2	158.2	356

FIG. 4 Insulated Water Bath

2-in. (50-mm), 1 1/2-in. (37.5-mm), 1-in. (25.0-mm), 3/4-in. (19.0-mm), 1/2-in. (12.5-mm), No. 4 (4.75-mm), and No. 10 sieves, or as many as may be needed depending on the sample, or upon the specifications for the material under test.

6.2 Conduct the sieving operation by means of a lateral and vertical motion of the sieve, accompanied by a jarring action in order to keep the sample moving continuously over the surface of the sieve. In no case turn or manipulate fragments in the sample through the sieve by hand. Continue sieving until not more than 1 mass % of the residue on a sieve passes that sieve during 1 min of sieving. When mechanical sieving is used, test the thoroughness of sieving by using the hand method of sieving as described above.

6.3 Determine the mass of each fraction on a balance conforming to the requirements of 3.1. At the end of weighing, the sum of the masses retained on all the sieves used should equal closely the original mass of the quantity sieved.

HYDROMETER AND SIEVE ANALYSIS OF PORTION PASSING THE NO. 10 (2.00-mm) SIEVE

Determination of Composite Correction for Hydrometer Reading

7.1 Equations for percentages of soil remaining in suspension, as given in 14.3, are based on the use of distilled or demineralized water. A dispersing agent is used in the water, however, and the specific gravity of the resulting liquid is appreciably greater than that of distilled or demineralized water.

7.1.1 Both soil hydrometers are calibrated at 68°F (20°C), and variations in temperature from this standard temperature produce inaccuracies in the actual hydrometer readings. The amount of the inaccuracy increases as the variation from the standard temperature increases.

7.1.2 Hydrometers are graduated by the manufacturer to be read at the bottom of the meniscus formed by the liquid on the stem. Since it is not possible to secure readings of soil suspensions at the bottom of the meniscus, readings must be taken at the top and a correction applied.

7.1.3 The net amount of the corrections for the three items enumerated is designated as the composite correction, and may be determined experimentally.

7.2 For convenience, a graph or table of composite corrections for a series of 1° temperature differences for the range of expected test temperatures may be prepared and used as needed. Measurement of the composite corrections may be made at two temperatures spanning the range of expected test temperatures, and corrections for the intermediate temperatures calculated assuming a straight-line relationship between the two observed values.

7.3 Prepare 1000 mL of liquid composed of distilled or demineralized water and dispersing agent in the same proportion as will prevail in the sedimentation (hydrometer) test. Place the liquid in a sedimentation cylinder and the cylinder in the constant-temperature water bath, set for one of the two temperatures to be used. When the temperature of the liquid becomes constant, insert the hydrometer, and, after a short interval to permit the hydrometer to come to the temperature of the liquid, read the hydrometer at the top of the meniscus formed on the stem. For hydrometer 151H the composite correction is the difference between this reading and one; for hydrometer 152H it is the difference between the reading and zero. Bring the liquid and the hydrometer to the other temperature to be used, and secure the composite correction as before.

8. Hygroscopic Moisture

8.1 When the sample is weighed for the hydrometer test, weigh out an auxiliary portion of from 10 to 15 g in a small metal or glass container, dry the sample to a constant mass in an oven at 230 ± 9°F (110 ± 5°C), and weigh again. Record the masses.

9. Dispersion of Soil Sample

9.1 When the soil is mostly of the clay and silt sizes, weigh out a sample of air-dry soil of approximately 50 g. When the soil is mostly sand the sample should be approximately 100 g.

9.2 Place the sample in the 250-mL beaker and cover with 125 mL of sodium hexametaphosphate solution (40 g/L). Stir until the soil is thoroughly wetted. Allow to soak for at least 16 h.

9.3 At the end of the soaking period, disperse the sample further, using either stirring apparatus A or B. If stirring apparatus A is used, transfer the soil - water slurry from the beaker into the special dispersion cup shown in Fig. 2, washing any residue from the beaker into the cup with distilled or demineralized water (Note 9). Add distilled or demineralized water, if necessary, so that the cup is more than half full. Stir for a period of 1 min.

NOTE 9—A large size syringe is a convenient device for handling the water in the washing operation. Other devices include the wash-water bottle and a hose with nozzle connected to a pressurized distilled water tank.

9.4 If stirring apparatus B (Fig. 3) is used, remove the cover cap and connect the cup to a compressed air supply by means of a rubber hose. A air gage must be on the line between the cup and the control valve. Open the control valve so that the gage indicates 1 psi (7 kPa) pressure (Note 10). Transfer the soil - water slurry from the beaker to the air-jet dispersion cup by washing with distilled or demineralized water. Add distilled or demineralized water, if necessary, so that the total volume in the cup is 250 mL, but no more.

NOTE 10—The initial air pressure of 1 psi is required to prevent the soil - water mixture from entering the air-jet chamber when the mixture is transferred to the dispersion cup.

9.5 Place the cover cap on the cup and open the air control valve until the gage pressure is 20 psi (140 kPa). Disperse the soil according to the following schedule:

Plasticity Index	Dispersion Period, min
Under 5	5
6 to 20	10
Over 20	15

Soils containing large percentages of mica need be dispersed for only 1 min. After the dispersion period, reduce the gage pressure to 1 psi preparatory to transfer of soil - water slurry to the sedimentation cylinder.

10. Hydrometer Test

10.1 Immediately after dispersion, transfer the soil - water slurry to the glass sedimentation cylinder, and add distilled or demineralized water until the total volume is 1000 mL.

10.2 Using the palm of the hand over the open end of the cylinder (or a rubber stopper in the open end), turn the cylinder upside down and back for a period of 1 min to complete the agitation of the slurry (Note 11). At the end of 1 min set the cylinder in a convenient location and take hydrometer readings at the following intervals of time (measured from the beginning of sedimentation), or as many as may be needed, depending on the sample or the specification for the material under test: 2, 5, 15, 30, 60, 250, and 1440 min. If the controlled water bath is used, the sedimentation cylinder should be placed in the bath between the 2- and 5-min readings.

NOTE 11—The number of turns during this minute should be approximately 60, counting the turn upside down and back as two turns.

Any soil remaining in the bottom of the cylinder during the first few turns should be loosened by vigorous shaking of the cylinder while it is in the inverted position.

10.3 When it is desired to take a hydrometer reading, carefully insert the hydrometer about 20 to 25 s before the reading is due to approximately the depth it will have when the reading is taken. As soon as the reading is taken, carefully remove the hydrometer and place it with a spinning motion in a graduate of clean distilled or demineralized water.

NOTE 12—It is important to remove the hydrometer immediately after each reading. Readings shall be taken at the top of the meniscus formed by the suspension around the stem, since it is not possible to secure readings at the bottom of the meniscus.

10.4 After each reading, take the temperature of the suspension by inserting the thermometer into the suspension.

11. Sieve Analysis

11.1 After taking the final hydrometer reading, transfer the suspension to a No. 200 (75- μ m) sieve and wash with tap water until the wash water is clear. Transfer the material on the No. 200 sieve to a suitable container, dry in an oven at $230 \pm 9^\circ\text{F}$ ($110 \pm 5^\circ\text{C}$) and make a sieve analysis of the portion retained, using as many sieves as desired, or required for the material, or upon the specification of the material under test.

CALCULATIONS AND REPORT

12. Sieve Analysis Values for the Portion Coarser than the No. 10 (2.00-mm) Sieve

12.1 Calculate the percentage passing the No. 10 sieve by dividing the mass passing the No. 10 sieve by the mass of soil originally split on the No. 10 sieve, and multiplying the result by 100. To obtain the mass passing the No. 10 sieve, subtract the mass retained on the No. 10 sieve from the original mass.

12.2 To secure the total mass of soil passing the No. 4 (4.75-mm) sieve, add to the mass of the material passing the No. 10 sieve the mass of the fraction passing the No. 4 sieve and retained on the No. 10 sieve. To secure the total mass of soil passing the $\frac{3}{8}$ -in. (9.5-mm) sieve, add to the total mass of soil passing the No. 4 sieve, the mass of the fraction passing the $\frac{3}{8}$ -in. sieve and retained on the No. 4 sieve. For the remaining sieves, continue the calculations in the same manner.

12.3 To determine the total percentage passing for each sieve, divide the total mass passing (see 12.2) by the total mass of sample and multiply the result by 100.

13. Hygroscopic Moisture Correction Factor

13.1 The hygroscopic moisture correction factor is the ratio between the mass of the oven-dried sample and the air-dry mass before drying. It is a number less than one, except when there is no hygroscopic moisture.

14. Percentages of Soil in Suspension

14.1 Calculate the oven-dry mass of soil used in the hydrometer analysis by multiplying the air-dry mass by the hygroscopic moisture correction factor.

TABLE 1 Values of Correction Factor, α , for Different Specific Gravities of Soil Particles^A

Specific Gravity	Correction Factor ^A
2.95	0.94
2.90	0.95
2.85	0.96
2.80	0.97
2.75	0.98
2.70	0.99
2.65	1.00
2.60	1.01
2.55	1.02
2.50	1.03
2.45	1.05

^A For use in equation for percentage of soil remaining in suspension when using Hydrometer 152H.

14.2 Calculate the mass of a total sample represented by the mass of soil used in the hydrometer test, by dividing the oven-dry mass used by the percentage passing the No. 10 (2.00-mm) sieve, and multiplying the result by 100. This value is the weight W in the equation for percentage remaining in suspension.

14.3 The percentage of soil remaining in suspension at the level at which the hydrometer is measuring the density of the suspension may be calculated as follows (Note 13): For hydrometer 151H:

$$P = \{(100\,000/W') \times G/(G - G_1)\}(R - G_1)$$

NOTE 13—The bracketed portion of the equation for hydrometer 151H is constant for a series of readings and may be calculated first and then multiplied by the portion in the parentheses.

For hydrometer 152H:

$$P = (Ra/W') \times 100$$

where:

- a = correction factor to be applied to the reading of hydrometer 152H. (Values shown on the scale are computed using a specific gravity of 2.65. Correction factors are given in Table 1),
- P = percentage of soil remaining in suspension at the level at which the hydrometer measures the density of the suspension,
- R = hydrometer reading with composite correction applied (Section 7),
- W = oven-dry mass of soil in a total test sample represented by mass of soil dispersed (see 14.2), g,
- G = specific gravity of the soil particles, and
- G_1 = specific gravity of the liquid in which soil particles are suspended. Use numerical value of one in both instances in the equation. In the first instance any possible variation produces no significant effect, and in the second instance, the composite correction factor is based on a value of one for G_1 .

15. Diameter of Soil Particles

15.1 The diameter of a particle corresponding to the percentage indicated by a given hydrometer reading shall be calculated according to Stokes' law (Note 14), on the basis that a particle of this diameter was at the surface of the suspension at the beginning of sedimentation and had settled to the level at which the hydrometer is measuring the density of the suspension. According to Stokes' law:

$$D = \sqrt{[30n/980(G - G_1)] \times L/T}$$

000040

where:

- η = diameter of particle, mm,
 = coefficient of viscosity of the suspending medium (in this case water) in poises (varies with changes in temperature of the suspending medium),
 L = distance from the surface of the suspension to the level at which the density of the suspension is being measured, cm. (For a given hydrometer and sedimentation cylinder, values vary according to the hydrometer readings. This distance is known as effective depth (Table 2)),
 T = interval of time from beginning of sedimentation to the taking of the reading, min,
 G = specific gravity of soil particles, and
 G_1 = specific gravity (relative density) of suspending medium (value may be used as 1.000 for all practical purposes).

NOTE 14—Since Stokes' law considers the terminal velocity of a single sphere falling in an infinity of liquid, the sizes calculated represent the diameter of spheres that would fall at the same rate as the soil particles.

15.2 For convenience in calculations the above equation may be written as follows:

$$D = K\sqrt{L/T}$$

where:

K = constant depending on the temperature of the suspension and the specific gravity of the soil particles. Values of K for a range of temperatures and specific gravities are given in Table 3. The value of K does not change for a series of readings constituting a test, while values of L and T do vary.

15.3 Values of D may be computed with sufficient accuracy, using an ordinary 10-in. slide rule.

NOTE 15—The value of L is divided by T using the A - and B -scales, the square root being indicated on the D -scale. Without ascertaining the value of the square root it may be multiplied by K , using either the C - or D -scale.

16. Sieve Analysis Values for Portion Finer than No. 10 (2.00-mm) Sieve

16.1 Calculation of percentages passing the various sieves used in sieving the portion of the sample from the hydrometer test involves several steps. The first step is to calculate the mass of the fraction that would have been retained on the No. 10 sieve had it not been removed. This mass is equal to the total percentage retained on the No. 10 sieve (100 minus total percentage passing) times the mass of the total sample represented by the mass of soil used (as calculated in 14.2), and the result divided by 100.

16.2 Calculate next the total mass passing the No. 200 sieve. Add together the fractional masses retained on all the sieves, including the No. 10 sieve, and subtract this sum from the mass of the total sample (as calculated in 14.2).

16.3 Calculate next the total masses passing each of the other sieves, in a manner similar to that given in 12.2.

16.4 Calculate last the total percentages passing by dividing the total mass passing (as calculated in 16.3) by the total mass of sample (as calculated in 14.2), and multiply the result by 100.

TABLE 2 Values of Effective Depth Based on Hydrometer and Sedimentation Cylinder of Specified Sizes^a

Hydrometer 151H		Hydrometer 152H			
Actual Hydrometer Reading	Effective Depth, L, cm	Actual Hydrometer Reading	Effective Depth, L, cm	Actual Hydrometer Reading	Effective Depth, L, cm
1.000	16.3	0	16.3	31	11.2
1.001	16.0	1	16.1	32	11.1
1.002	15.8	2	16.0	33	10.9
1.003	15.5	3	15.8	34	10.7
1.004	15.2	4	15.6	35	10.6
1.005	15.0	5	15.5		
1.006	14.7	6	15.3	36	10.4
1.007	14.4	7	15.2	37	10.2
1.008	14.2	8	15.0	38	10.1
1.009	13.9	9	14.8	39	9.9
1.010	13.7	10	14.7	40	9.7
1.011	13.4	11	14.5	41	9.6
1.012	13.1	12	14.3	42	9.4
1.013	12.9	13	14.2	43	9.2
1.014	12.6	14	14.0	44	9.1
1.015	12.3	15	13.8	45	8.9
1.016	12.1	16	13.7	46	8.8
1.017	11.8	17	13.5	47	8.6
1.018	11.5	18	13.3	48	8.4
1.019	11.3	19	13.2	49	8.3
1.020	11.0	20	13.0	50	8.1
1.021	10.7	21	12.9	51	7.9
1.022	10.5	22	12.7	52	7.8
1.023	10.2	23	12.5	53	7.6
1.024	10.0	24	12.4	54	7.4
1.025	9.7	25	12.2	55	7.3
1.026	9.4	26	12.0	56	7.1
1.027	9.2	27	11.9	57	7.0
1.028	8.9	28	11.7	58	6.8
1.029	8.6	29	11.5	59	6.6
1.030	8.4	30	11.4	60	6.5
1.031	8.1				
1.032	7.8				
1.033	7.6				
1.034	7.3				
1.035	7.0				
1.036	6.8				
1.037	6.5				
1.038	6.2				

^a Values of effective depth are calculated from the equation:

$$L = L_1 + \frac{1}{2} [L_2 - (V_b/A)]$$

where:

- L = effective depth, cm,
 L_1 = distance along the stem of the hydrometer from the top of the bulb to the mark for a hydrometer reading, cm,
 L_2 = overall length of the hydrometer bulb, cm,
 V_b = volume of hydrometer bulb, cm³, and
 A = cross-sectional area of sedimentation cylinder, cm²

Values used in calculating the values in Table 2 are as follows:

For both hydrometers, 151H and 152H:

L_2 = 14.0 cm

V_b = 67.0 cm³

A = 27.8 cm²

For hydrometer 151H:

L_1 = 10.5 cm for a reading of 1.000

= 2.3 cm for a reading of 1.031

For hydrometer 152H:

L_1 = 10.5 cm for a reading of 0 g/litre

= 2.3 cm for a reading of 50 g/litre

17. Graph

17.1 When the hydrometer analysis is performed, a graph

TABLE 3 Values of K for Use in Equation for Computing Diameter of Particle in Hydrometer Analysis

Temperature, °C	Specific Gravity of Soil Particles								
	2.45	2.50	2.55	2.60	2.65	2.70	2.75	2.80	2.85
16	0.01510	0.01505	0.01481	0.01457	0.01435	0.01414	0.01394	0.01374	0.01356
17	0.01511	0.01486	0.01462	0.01439	0.01417	0.01396	0.01376	0.01356	0.01338
18	0.01492	0.01467	0.01443	0.01421	0.01399	0.01378	0.01359	0.01339	0.01321
19	0.01474	0.01449	0.01425	0.01403	0.01382	0.01361	0.01342	0.1323	0.01305
20	0.01456	0.01431	0.01408	0.01386	0.01365	0.01344	0.01325	0.01307	0.01289
21	0.01438	0.01414	0.01391	0.01369	0.01348	0.01328	0.01309	0.01291	0.01273
22	0.01421	0.01397	0.01374	0.01353	0.01332	0.01312	0.01294	0.01276	0.01258
23	0.01404	0.01381	0.01358	0.01337	0.01317	0.01297	0.01279	0.01261	0.01243
24	0.01388	0.01365	0.01342	0.01321	0.01301	0.01282	0.01264	0.01246	0.01229
25	0.01372	0.01349	0.01327	0.01306	0.01286	0.01267	0.01249	0.01232	0.01215
26	0.01357	0.01334	0.01312	0.01291	0.01272	0.01253	0.01235	0.01218	0.01201
27	0.01342	0.01319	0.01297	0.01277	0.01258	0.01239	0.01221	0.01204	0.01188
28	0.01327	0.01304	0.01283	0.01264	0.01244	0.01225	0.01208	0.01191	0.01175
29	0.01312	0.01290	0.01269	0.01249	0.01230	0.01212	0.01195	0.01178	0.01162
30	0.01298	0.01276	0.01256	0.01236	0.01217	0.01199	0.01182	0.01165	0.01149

of the test results shall be made, plotting the diameters of the particles on a logarithmic scale as the abscissa and the percentages smaller than the corresponding diameters to an arithmetic scale as the ordinate. When the hydrometer analysis is not made on a portion of the soil, the preparation of the graph is optional, since values may be secured directly from tabulated data.

18. Report

18.1 The report shall include the following:

18.1.1 Maximum size of particles,

18.1.2 Percentage passing (or retained on) each sieve, which may be tabulated or presented by plotting on a graph (Note 16),

18.1.3 Description of sand and gravel particles:

18.1.3.1 Shape—rounded or angular,

18.1.3.2 Hardness—hard and durable, soft, or weathered and friable.

18.1.4 Specific gravity, if unusually high or low,

18.1.5 Any difficulty in dispersing the fraction passing the No. 10 (2.00-mm) sieve, indicating any change in type and amount of dispersing agent, and

18.1.6 The dispersion device used and the length of the dispersion period.

NOTE 16—This tabulation of graph represents the gradation of the sample tested. If particles larger than those contained in the sample were removed before testing, the report shall so state giving the amount and maximum size.

18.2 For materials tested for compliance with definite specifications, the fractions called for in such specifications shall be reported. The fractions smaller than the No. 10 sieve shall be read from the graph.

18.3 For materials for which compliance with definite specifications is not indicated and when the soil is composed

almost entirely of particles passing the No. 4 (4.75-mm) sieve, the results read from the graph may be reported as follows:

- | | |
|--|---------|
| (1) Gravel, passing 3-in. and retained on No. 4 sieve | % |
| (2) Sand, passing No. 4 sieve and retained on No. 200 sieve | % |
| (a) Coarse sand, passing No. 4 sieve and retained on No. 10 sieve | % |
| (b) Medium sand, passing No. 10 sieve and retained on No. 40 sieve | % |
| (c) Fine sand, passing No. 40 sieve and retained on No. 200 sieve | % |
| (3) Silt size, 0.074 to 0.005 mm | % |
| (4) Clay size, smaller than 0.005 mm | % |
| Colloids, smaller than 0.001 mm | % |

18.4 For materials for which compliance with definite specifications is not indicated and when the soil contains material retained on the No. 4 sieve sufficient to require a sieve analysis on that portion, the results may be reported as follows (Note 17):

SIEVE ANALYSIS

Sieve Size	Percentage Passing
3-in.
2-in.
1½-in.
1-in.
¾-in.
½-in.
No. 4 (4.75-mm)
No. 10 (2.00-mm)
No. 40 (425-µm)
No. 200 (75-µm)

HYDROMETER ANALYSIS

0.074 mm
0.005 mm
0.001 mm

NOTE 17—No. 8 (2.36-mm) and No. 50 (300-µm) sieves may be substituted for No. 10 and No. 40 sieves.

The American Society for Testing and Materials takes no position respecting the validity of any patent rights asserted in connection with any item mentioned in this standard. Users of this standard are expressly advised that determination of the validity of any such patent rights, and the risk of infringement of such rights, are entirely their own responsibility.

This standard is subject to revision at any time by the responsible technical committee and must be reviewed every five years and if not revised, either reapproved or withdrawn. Your comments are invited either for revision of this standard or for additional standards and should be addressed to ASTM Headquarters. Your comments will receive careful consideration at a meeting of the responsible technical committee, which you may attend. If you feel that your comments have not received a fair hearing you should make your views known to the ASTM Committee on Standards, 1916 Race St., Philadelphia, PA 19103.



Standard Practice for Dry Preparation of Soil Samples for Particle-Size Analysis and Determination of Soil Constants¹

This standard is issued under the fixed designation D 421; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ϵ) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This practice covers the dry preparation of soil samples as received from the field for particle-size analysis and the determination of the soil constants.

1.2 *This standard may involve hazardous materials, operations, and equipment. This standard does not purport to address all of the safety problems associated with its use. It is the responsibility of whoever uses this standard to consult and establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 ASTM Standards:

D 2217 Practice for Wet Preparation of Soil Samples for Particle-Size Analysis and Determination of Soil Constants²

E 11 Specification for Wire-Cloth Sieves for Testing Purposes³

3. Significance and Use

3.1 This practice can be used to prepare samples for particle-size and plasticity tests where it is desired to determine test values on air-dried samples, or where it is known that air drying does not have an effect on test results relative to samples prepared in accordance with Practice D 2217.

4. Apparatus

4.1 *Balance*, sensitive to 0.1 g.

4.2 *Mortar and Rubber-Covered Pestle*, suitable for breaking up the aggregations of soil particles.

4.3 *Sieves*—A series of sieves, of square mesh woven wire cloth, conforming to Specification E 11. The sieves required are as follows:

No. 4 (4.75-mm)
No. 10 (2.00-mm)
No. 40 (425- μ m)

4.4 *Sampler*—A riffle sampler or sample splitter, for quartering the samples.

5. Sampling

5.1 Expose the soil sample as received from the field to the

air at room temperature until dried thoroughly. Break up the aggregations thoroughly in the mortar with a rubber-covered pestle. Select a representative sample of the amount required to perform the desired tests by the method of quartering or by the use of a sampler. The amounts of material required to perform the individual tests are as follows:

5.1.1 *Particle-Size Analysis*—For the particle-size analysis, material passing a No. 10 (2.00-mm) sieve is required in amounts equal to 115 g of sandy soils and 65 g of either silt or clay soils.

5.1.2 *Tests for Soil Constants*—For the tests for soil constants, material passing the No. 40 (425- μ m) sieve is required in total amount of 220 g, allocated as follows:

Test	Grams
Liquid limit	100
Plastic limit	15
Centrifuge moisture equivalent	10
Volumetric shrinkage	30
Check tests	65

6. Preparation of Test Sample

6.1 Select that portion of the air-dried sample selected for purpose of tests and record the mass as the mass of the total test sample uncorrected for hygroscopic moisture. Separate the test sample by sieving with a No. 10 (2.00-mm) sieve. Grind that fraction retained on the No. 10 sieve in a mortar with a rubber-covered pestle until the aggregations of soil particles are broken up into the separate grains. Then separate the ground soil into two fractions by sieving with a No. 10 sieve.

6.2 Wash that fraction retained after the second sieving free of all fine material, dry, and weigh. Record this mass as the mass of coarse material. Sieve the coarse material, after being washed and dried, on the No. 4 (4.75-mm) sieve and record the mass retained on the No. 4 sieve.

7. Test Sample for Particle-Size Analysis

7.1 Thoroughly mix together the fractions passing the No. 10 (2.00-mm) sieve in both sieving operations, and by the method of quartering or the use of a sampler, select a portion weighing approximately 115 g for sandy soils and approximately 65 g for silt and clay soil for particle-size analysis.

8. Test Sample for Soil Constants

8.1 Separate the remaining portion of the material passing the No. 10 (2.00-mm) sieve into two parts by means of a No. 40 (425- μ m) sieve. Discard the fraction retained on the No. 40 sieve. Use the fraction passing the No. 40 sieve for the determination of the soil constants.

¹ This practice is under the jurisdiction of ASTM Committee D-18 on Soil and Rock and is the direct responsibility of Subcommittee D18.03 on Texture, Plasticity, and Density Characteristics of Soils.

Current edition approved July 26, 1985. Published September 1985. Originally published as D 421 - 35 T. Last previous edition D 421 - 58 (1978)¹.

² Annual Book of ASTM Standards, Vol 04.08.

³ Annual Book of ASTM Standards, Vol 14.02.

Standard Method for Laboratory Determination of Water (Moisture) Content of Soil, Rock, and Soil-Aggregate Mixtures¹

This standard is issued under the fixed designation D 2216; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ϵ) indicates an editorial change since the last revision or reapproval.

Scope

1 This method covers the laboratory determination of water (moisture) content of soil, rock, and soil-aggregate mixtures by weight. For simplicity, the word "material" hereinafter refers to either soil, rock, or soil-aggregate mixtures, whichever is most applicable.

2 The water content of a material is defined as the ratio, expressed as a percentage, of the mass of "pore" or "free" water in a given mass of material to the mass of the solid material particles.

3 This method does not give true representative results for materials containing significant amounts of halloysite, attapulgite, or gypsum minerals; highly organic soils; materials in which the pore water contains dissolved salts (such as salt in the case of marine deposits). For a material of the previously mentioned types, a modified method of testing or data calculation may be established to give results consistent with the purpose of the test.

Summary of Method

1 The practical application in determining the water content of a material is to determine the mass of water removed by drying the moist material (test specimen) to a constant mass in a drying oven controlled at $110 \pm 5^\circ\text{C}$ and use this value as the mass of water in the test specimen. The mass of material remaining after oven-drying is used as the mass of the solid particles.

Significance and Use

1 For many soil types, the water content is one of the significant index properties used in establishing a relation between soil behavior and an index property.

2 The water content of a soil is used in almost every relation expressing the phase relationships of air, water, and solids in a given volume of material.

3 In fine-grained (cohesive) soils, the consistency of a soil type depends on its water content. The water content of a soil, along with its liquid and plastic limit, is used to express its relative consistency or liquidity index.

4 The term "water" as used in geotechnical engineering, is typically assumed to be "pore" or "free" water and not water which is hydrated to the mineral surfaces. Therefore, the water content of materials containing significant amounts of

hydrated water at in-situ temperatures or less than 110°C can be misleading.

3.5 The term "solid particles" as used in geotechnical engineering, is typically assumed to mean naturally occurring mineral particles that are not readily soluble in water. Therefore, the water content of materials containing extraneous matter (such as cement, etc), water-soluble matter (such as salt) and highly organic matter typically require special treatment or a qualified definition of water content.

4. Apparatus

4.1 *Drying Oven*, thermostatically-controlled, preferably of the forced-draft type, and maintaining a uniform temperature of $110 \pm 5^\circ\text{C}$ throughout the drying chamber.

4.2 *Balances*, having a precision (repeatability) of ± 0.01 g for specimens having a mass of 200 g or less, ± 0.1 g for specimens having a mass of between 200 and 1000 g, or ± 1 g for specimens having a mass greater than 1000 g.

4.3 *Specimen Containers*—Suitable containers made of material resistant to corrosion and a change in mass upon repeated heating, cooling, and cleaning. Containers with close-fitting lids shall be used for testing specimens having a mass of less than about 200 g; while for specimens having a mass greater than about 200 g, containers without lids may be used (Note 1). One container is needed for each water content determination.

NOTE 1—The purpose of close-fitting lids is to prevent loss of moisture from specimens before initial weighing and to prevent absorption of moisture from the atmosphere following drying and before final weighing.

4.4 *Desiccator*—A desiccator of suitable size (a convenient size is 200 to 250-mm diameter) containing a hydrous silica gel. This equipment is only recommended for use when containers having close-fitting lids are not used. See 7.4.1.

5. Samples

5.1 Keep the samples that are stored prior to testing in noncorrodible airtight containers at a temperature between approximately 3 and 30°C and in an area that prevents direct contact with sunlight.

5.2 The water content determination should be done as soon as practicable after sampling, especially if potentially corrodible containers (such as steel thin-walled tubes, paint cans, etc.) or sample bags are used.

6. Test Specimen

6.1 For water contents being determined in conjunction with another ASTM method, the method of specimen selection specified in that method controls.

¹This method is under the jurisdiction of ASTM Committee D-18 on Soil and Rocks and is the direct responsibility of Subcommittee D18.03 on Texture, Density and Density Characteristics of Soils.
Test edition approved May 30, 1980. Published July 1980. Originally published as D 2216 - 63 T. Last previous edition D 2216 - 71.

6.2 The manner in which the test specimen is selected and its required mass is basically dependent on the purpose (application) of the test, type of material being tested, and the type of sample (specimen from another test, bag, tube, split-barrel, etc.). In all cases, however, a representative portion of the total sample shall be selected. If a layered soil or more than one soil type is encountered, select an average portion or individual portions or both, and note which portion(s) was tested in the report of the results.

6.2.1 For bulk samples, select the test specimen from the material after it has been thoroughly mixed. The mass of moist material selected shall be in accordance with the following table:

Sieve Retaining More Than About 10 % of Sample	Recommended Minimum Mass of Moist Specimen, g
2.0 mm (No. 10) sieve	100 to 200
4.75 mm (No. 4) sieve	300 to 500
19 mm	500 to 1000
38 mm	1500 to 3000
76 mm	5000 to 10 000

6.2.2 For small (jar) samples, select a representative portion in accordance with the following procedure:

6.2.2.1 For cohesionless soils, thoroughly mix the material, then select a test specimen having a mass of moist material in accordance with the table in 6.2.1. See Note 2.

6.2.2.2 For cohesive soils, remove about 3 mm of material from the exposed periphery of the sample and slice it in half (to check if the material is layered) prior to selecting the test specimen. If the soil is layered see 6.2. The mass of moist material selected should not be less than 25 g or should be in accordance with the table in 6.2.1 if coarse-grained particles are noted. (Note 2).

6.3 Using a test specimen smaller than the minimum mass indicated previously requires discretion, though it may be adequate for the purpose of the test. A specimen having a mass less than the previously indicated value shall be noted in the report of the results.

NOTE 2—In many cases, when working with a small sample containing a relatively large coarse-grained particle, it is appropriate not to include this particle in the test specimen. If this occurs, it should be noted in the report of the results.

7. Procedure

7.1 Select representative test specimens in accordance with Section 6.

7.2 Place the moist specimen in a clean, dry container of known mass (Note 3), set the lid securely in position, and determine the mass of the container and moist material using an appropriate balance (4.2). Record these values.

7.3 Remove the lid and place the container with moist material in a drying oven maintained at $110 \pm 5^\circ\text{C}$ and dry to a constant mass (Notes 4, 5, and 6).

NOTE 3—To assist in the oven-drying of large test specimens, they should be placed in containers having a large surface area (such as pans) and the material broken up into smaller aggregations.

NOTE 4—The time required to obtain constant mass will vary depending on the type of material, size of specimen, oven type and capacity, and other factors. The influence of these factors generally can be established by good judgment, and experience with the materials being tested and the apparatus being used. In most cases, drying a test specimen over night (about 16 h) is sufficient. In cases where there is doubt concerning the adequacy of drying, drying should be continued until the mass after two successive periods (greater than $\frac{1}{2}$ h) of drying

indicate an insignificant change (less than about 0.1 %). Specimens of sand may often be dried to constant mass in a period of about 4 h, when a forced-draft oven is used.

NOTE 5—Oven-drying at $110 \pm 5^\circ\text{C}$ does not always result in water content values related to the intended use or the basic definition, especially for materials containing gypsum or other minerals having significant amounts of hydrated water or for soil containing a significant amount of organic material. In many cases, and depending on the intended use for these types of materials, it might be more applicable to maintain the drying oven at $60 \pm 5^\circ\text{C}$ or use a vacuum desiccator at a vacuum of approximately 133 Pa (10 mm Hg) and at a temperature ranging between 23 and 60°C for drying. If either of these drying methods are used, it should be noted in the report of the results.

NOTE 6—Since some dry materials may absorb moisture from moist specimens, dried specimens should be removed before placing moist specimens in the oven. However, this requirement is not applicable if the previously dried specimens will remain in the drying oven for an additional time period of about 16 h.

7.4 After the material has dried to constant mass remove the container from the oven and replace the lid. Allow the material and container to cool to room temperature or until the container can be handled comfortably with bare hands and the operation of the balance will not be affected by convection currents. Determine the mass of the container and oven-dried material using the same balance as used in 7.2. Record this value.

7.4.1 If the container does not have a lid, weigh the container and material right after their temperatures are such that the operation of the balance will not be affected by convection currents or after cooling in a desiccator.

NOTE 7—Cooling in a desiccator is recommended since it prevents absorption of moisture from the atmosphere during cooling.

8. Calculation

8.1 Calculate the water content of the material as follows:

$$w = [(W_1 - W_2)/(W_2 - W_c)] \times 100 = \frac{W_w}{W_s} \times 100$$

where:

w = water content, %,
 W_1 = mass of container and moist specimen, g,
 W_2 = mass of container and oven-dried specimen, g,
 W_c = mass of container, g,
 W_w = mass of water, g, and
 W_s = mass of solid particles, g.

9. Report

9.1 The report (data sheet) shall include the following:

9.1.1 Identification of the sample (material) being tested by boring number, sample number, test number, etc.

9.1.2 Water content of the specimen to the nearest 0.1 or 1 %, depending on the purpose of the test.

9.1.3 Indication of test specimen having a mass less than the minimum indicated in Section 6.

9.1.4 Indication of test specimen containing more than one soil type (layered, etc).

9.1.5 Indication of the method of drying if different from oven-drying at $110 \pm 5^\circ\text{C}$.

9.1.6 Indication of any material (size and amount) excluded from the test specimen.

10. Precision and Accuracy

10.1 Requirements for the precision and accuracy of this test method have not yet been developed.

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APPENDIX C

**FIELD INVESTIGATION
STANDARD OPERATING PROCEDURES**



Knowledge, and the Creativity to Use It

44808 Helm St. Plymouth, MI 48170 (313) 454-1100 Fax. 454-1233

STATIC WATER LEVEL MEASUREMENT BY ELECTRONIC DEPTH INDICATOR

STANDARD OPERATING PROCEDURE

Scope

This sop is to be used for the measurement of the distance between the top-of-casing elevation and the static water level in groundwater monitoring wells. This measurement can then be used in combination with a site survey datum to determine static water elevation.

Equipment

- 1 - Electronic depth indicator with battery
- 1 - bottle of tap water
- Clean toweling;
- 1 - Spray bottle of laboratory grade soap solution;
- 1 - Spray bottle of deionized, organic-free rinse water.

Procedure

Prior to each day's use, the proper operation of the electronic depth indicator must be verified. Insert the sensor end of the tape into a bottle of tap water and verify that the audio and/or visual signals are operating properly. Remove the sensor to verify that the audio and/or visual signals are terminated. If the signals do not operate, or their intensity is weak, replace the battery. If this fails to correct the problem, refer to the indicator's maintenance manual for appropriate repair procedures.

Locate and identify the monitoring well for measurement.

Insert the sensor end of the indicator into the well and lower it until the audio and/or visual signals are activated. Raise the tape until the signal(s) just deactivate. Repeat these steps until the slightest movement of the tape activates or deactivates the signals. Note the distance on the tape at the top of the well casing to the nearest 0.01" and record this datum in the field log. This measurement is called the static water level.

Repeat the entire procedure described above to obtain two additional measurements of the static water level.

The static water elevation is determined according to the following equation:

$$\text{SWE} = \text{TOC} - \text{SWL}$$

where SWE = Static Water Elevation,
 TOC = Top of Casing Elevation
 SWL = Static Water Level



Knowledge, and the Creativity to Use It

44808 Helm St. Plymouth, MI 48170 (313) 454-1100 Fax: 454-1233

STATIC WATER LEVEL MEASUREMENT BY WET TAPE METHOD

STANDARD OPERATING PROCEDURE

Scope

This SOP is to be used for the measurement of the distance between the top-of-casing elevation and the static water level in groundwater monitoring wells. This measurement can then be used in combination with a site survey datum to determine static water elevation.

Equipment

- 1 - Steel engineer's tape with weighted end;
- Carpenters chalk;
- Clean toweling;
- 1 - Spray bottle of laboratory grade soap solution;
- 1 - Spray bottle of deionized, organic-free rinse water.

Procedure

Locate and identify the monitoring well for measurement.

Lightly coat approximately four feet, measured from the weighted end, of the engineer's tape with carpenter's chalk. Slowly lower the tape into the monitoring well until an audio response indicates that the weighted end has entered the groundwater. The tape is then lowered into the well casing until the next whole foot mark is aligned with the top of the well casing. This foot mark is called the hold mark and is recorded in the field log. The tape is then carefully removed so as to prevent any additional tape from entering the water. Retrieval of the tape must be terminated before the wetted part of the tape enters the tape holder or is otherwise degraded. After retrieval, the wet/dry interface is noted, and the tape measurement is recorded to the nearest 0.01 foot. This measurement is called the read value.

The tape is then washed with detergent solution and rinsed with organic-free deionized water prior to re-use.

The static water level is now determined according to the following equation:

$$SWL = HV - RV$$

where SWL = Static Water Level,
HV = Hold Value, and
RV = Read Value.

The static water elevation is determined according to the following equation:

$$SWE = TOC - SWL$$

where SWE = Static Water Elevation,
TOC = Top of Casing Elevation
SWL = Static Water Level



Knowledge, and the Creativity to Use It

44808 Helm St. Plymouth, MI 48170 (313) 454-1100 Fax: 454-1233

Determination of Porosity of fine aggregate
in a saturated and drained condition

Alternate Methods

Method 1:

Obtain field samples in split spoons with segmented brass liners.

Seal liners and samples with parafin in field.

Deliver sealed liner samples to laboratory.

Separate middle segment uninfluenced by parafin.

Segment has predetermined volume.

Weight of sample divided by volume equals density.

Fill permeability mold of known volume and weight with sufficient weight of sampled granular aggregate to achieve field density condition.

Fill device with water to top.

Open side pet cock allowing water to drain into beaker or graduate.

Measure or weigh drained water.

Specific yield = $\frac{V_g}{V}$
(Porosity)

Method 2:

Determine approximate density of granular material based on standard penetration blow count or from liner samples determined as in method 1.

Simulate approximate density condition in laboratory in Proctor mold with bottom side pet cock.

Fill voids in mold, containing granular sample at simulated density with water.

Allow water to drain out of pet cock.

Perform specific gravity on portion of granular sample in saturated drained condition. (ASTM C-128)

000005

$$\text{SPECIFIC GRAVITY} = \frac{\text{Wt}}{\text{Vol}} = \frac{\text{Weight of Saturated Drained Sand}}{\text{Volume}}$$

$$\text{Volume} = 1\text{ft}^3$$

$$\text{Vol of Solids in Drained Condiiton} = \frac{\text{Approximated field density \#/ft}^3}{\text{Specific gravity in drained condition} \times 62.4 \text{ \#/ft}^3}$$

Approximate
insitu

$$\frac{\text{Field Density \#/ft}^3}{\text{Solid Density \#/ft}^3} = \text{Volume of Solids in Drained condition}$$

$$\text{Volume of Voids} = 1 - \text{Volume of Solids in Drained Condition}$$

$$\text{Specific Yield (Porosity)} = \frac{1 - \text{Volume of Solids in Drained Condition}}{1}$$



Knowledge, and the Creativity to Use It

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HYDRAULIC CONDUCTIVITY BY THE SLUG TEST METHOD

STANDARD OPERATING PROCEDURE

INTRODUCTION

Applicability: This method is applicable to the measurement of saturated hydraulic conductivity in earth materials. The saturated zones may be confined or unconfined.

Purpose: Hydraulic conductivity is an important physical characteristic of saturated zones; it is used in estimating the potential rate of groundwater flow in aquifers, thus assisting the estimation of contaminant transport in such systems.

Reference Methods: USEPA Method 9100, SW-846.

Summary of Method: A known amount of groundwater is displaced from a monitoring well. The rate of rise of the water level in a groundwater monitoring well is then measured and then mathematically converted to a determination of hydraulic conductivity.

Safety Precautions: General field safety requirements where chemical contamination of the groundwater is not suspected. Protective clothing, rubber gloves and compliance with site safety plan where chemical contamination is suspected or known.

Apparatus:

- 1 - Displacement Probe (0.5, 1.0 or 2.0 gallon-equivalent as appropriate for volume of water in the well);
- 1 - Hermit 1000B Data Logger with Pressure Transducer;
- 1 - bottle of tap water;
- Clean toweling;
- 1 - Spray bottle of laboratory grade soap solution;
- 1 - Spray bottle of deionized, organic-free rinse water.

PROCEDURE

Preparation: Measure the static water level using chalked tape or electronic water sensor procedure. Measure the depth to the bottom of the well using a measuring tape. Record all

measurements in the field log. Calculate the volume of water in the well according to the following equation:

$$\text{Volume (gal.)} = H \times 3.1416 \times R^2 \times 7.48 \quad \text{where}$$

H = height of water column in feet (static water level - depth of well bottom), and
R = 0.5 x inside diameter of well in feet.

Select the largest displacement probe such that the volume of displacement is $\leq 75\%$ of the static water volume in the monitoring well. Decontaminate the probe prior to use in each new well by washing with detergent and then rinsing with tap water and de-ionized water.

Attach pressure transducer connecting cables to the data logger and adjust gain, balance and zero according to instrument manual. Insert transducer to bottom of monitoring well and adjust data logger to stable reading according to instrument manual.

Testing: Insert the displacement probe into the well such that the top of the probe is at a level below the static water level in the well (see above). Allow the static water level to return to the equilibrium as indicated by the output of the pressure transducer. Set data logger to logarithmic sampling schedule. Quickly remove the probe. Continue data collection until static water level has returned to $\geq 85\%$ of original level. Output data to printer or microcomputer.

CALCULATIONS

Plot log (water level) vs. time after probe removal.

Determine hydraulic conductivity (K) from the following equation:

$$K = \frac{r_c^2 \times \ln(R_e/r_w) \times 1/t \times \ln(y_0/y_t)}{2L_e} \quad \text{where}$$

$$\ln(R_e/r_w) = \left[\frac{1.1}{\ln(L_w/r_w)} + \frac{A + B \ln[(H-L_w)/r_w]}{L_e/r_w} \right]^{-1} \quad \text{for } L_w < H$$

$$\ln(R_e/r_w) = \left[\frac{1.1}{\ln(L_w/r_w)} + \frac{C}{L_e/r_w} \right]^{-1}$$

L_e = length of screen

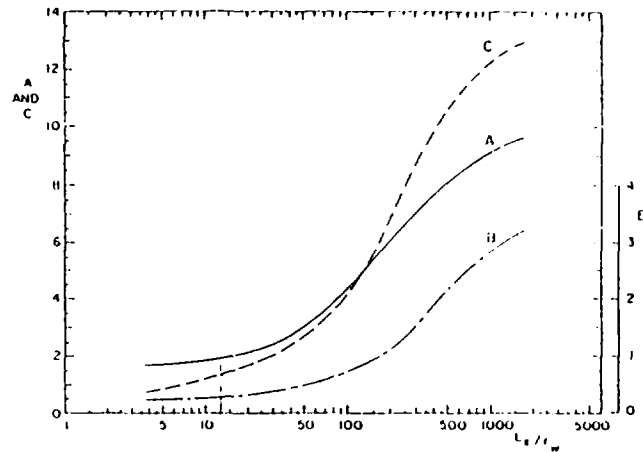
L_w = distance from bottom of screen to water table

y = vertical distance from water level inside well to water table

R_e = effective radial distance

r_w = radial distance to outer edge of sand pack

A, B, and C = constants determined from graph below



The values for y_0 , y_t and t should be derived from the straight portion of the plot derived in the first step of the calculations.

DATA DELIVERABLES

- Brief description of field procedures
- Raw data - values of y v. t
- Instrument logbook

QUALITY CONTROL REQUIREMENTS

Duplicate slug tests will be performed at the rate of one per ten or fewer tests conducted.

REFERENCES

- Bouwer, H., "The Bouwer and Rice Slug Test - An Update," Groundwater, 27 (3), 304 - 309.
- Bouwer, H. and R.C. Rice, "A Slug Test for Determining Hydraulic Conductivity of Unconfined Aquifers with Completely or Partially Penetrating Wells," Water Resources Research, 12, 423 - 428.

APPENDIX D

RESUMES OF KEY PERSONNEL

EDUCATION

Ph.D., Organic Chemistry, The University of Texas at Austin, 1975
B.A., Chemistry, Rice University, 1970

EXPERIENCE

* Summary

President, Techna Corporation	1986 - Date
Principal, Quantum Consultants	1985 - 1986
President, Environmental Research Group, Inc.	1984 - 1985
Program Manger, Radian Corporation	1982 - 1984
Department Head, Radian Corporation	1981 - 1982
Group Leader, Radian Corporation	1979 - 1981
Staff Scientist, Radian Corporation	1976 - 1979
Laboratory Design Consultant (part time)	1980 - 1983

* Techna Corporation, Ann Arbor, Michigan

President and senior technical manager of a company providing research and regulatory compliance services in all areas of environmental, hazardous waste, and hazardous chemicals activities. Projects have included oil spill decontamination and remediation, development of hazardous waste management programs, waste characterization and disposal, hazard communication programs, site contamination assessment and remedial action planning, industrial effluent analysis and management programs, and environmental audits. A large environmental chemistry laboratory was designed for the U.S. Army Corps of Engineers.

* Quantum Consultants, Ann Arbor, Michigan

Principal and senior project/technical manager providing technical services in the areas of hazardous waste management, hazardous chemicals management and environmental regulations compliance. Projects included environmental and safety audits, waste management programs, groundwater and effluent sampling and analysis, assessments of chemically contaminated plant sites, development of hazard communication compliance and training programs, and design of a pharmaceutical manufacturing facility.

* Environmental Research Group, Inc., Ann Arbor, Michigan

Activities as President and Chief Operating Officer included corporate and senior technical management for a technical consulting company (environmental, industrial hygiene, hazardous waste, and chemical analysis services) comprised of 120 staff members in five nationwide locations. Technical activities included project design and management in the areas of

hazardous waste management, analytical chemistry, waste site investigation, water pollution control, and chemical health and safety. Projects included assessments of chemically contaminated sites, development of efficient chemical analysis programs for groundwater and effluent monitoring projects, air and wastewater permit support, wastewater treatment system evaluations, development of hazardous waste management and delisting programs, and industrial hygiene surveys.

* Radian Corporation, Austin, Texas

Management and technical responsibilities included new business development, marketing, and design and management of projects ranging in size from \$10,000 to \$5 million. Business/technical areas of responsibility included hazardous waste programs, hazardous materials management and safety, analytical chemistry, data management, specialty chemical products, and pharmaceutical chemistry. Activities included design of quality assurance analytical standards programs for environmental analysis, development of chemical sampling and analysis procedures for environmental assessment of major industries, and development of hazardous materials handling facilities and safety programs. Other activities included hazardous waste site investigations, industrial hygiene surveys, chemical synthesis program development, and chemical analysis methods validations.

* Laboratory Design Consultant, Austin, Texas

The laboratory services and facilities of a major drinking water treatment facility were evaluated, a five-year expansion plan was developed, and a new 35,000 square foot laboratory and office complex was designed.

SPECIAL ACTIVITIES

Task Force for Scientific and Technical Assessments of Hazardous Waste Management, U.S. Intergovernmental Science, Engineering and Technology Advisory Panel, Washington, D.C., 1979.

Resource, Conservation and Recovery Act (RCRA) Task Force, American Chemical Society-Joint Committees, Washington, D.C., 1982 - present.

Small Quantity Generator Education Advisory Panel, Waste Systems Institute of Michigan, Inc./Michigan Department of Natural Resources, Lansing, Michigan, 1986 - present.

Symposium Organizer and Chair, American Chemical Society Annual Meetings:

- "Safety Concerns at Hazardous Waste Sites",
Kansas City, Missouri, September, 1982.
- "Hazardous Materials Safety in the Chemistry Laboratory",
St. Louis, Missouri, April, 1984.

Exposition Planning and Coordinating Committee, "Laboratory of the Future," Scientific Apparatus Manufacturers Association, 1983 - 1984.

Community Forum on Managing Small Quantities of Hazardous Waste, Washtenaw County, Michigan, 1986 - 1988.

AFFILIATIONS

American Chemical Society, American Association for the Advancement of Science, American Society for Testing and Materials.

JAMES M. HARLESS, Ph.D.

PUBLICATIONS

Cantrell, T.S., J.M. Harless and B.L. Strasser, "The Acetylation of Cyclononene," J. Org. Chem., 36, 1191 (1971).

Harless, J.M. and S.A. Monti, "Tricyclo[3.1.1.0^{3,6}]heptan-6- carboxylic Acid," J. Amer. Chem. Soc., 94, 4714 (1974).

Monti, S.A. and J.M. Harless, "Synthesis of Tricyclo- [3.1.1.0^{3,6}]heptan-6-yl Derivatives," J. Amer. Chem. Soc., 99, 2690 (1977).

Harless, J.M., K.E. Baxter, L.H. Keith and D.B. Walters, "Design and Operation of a Hazardous Materials Laboratory," in Safe Handling of Chemical Carcinogens, Mutagens and Teratogens, D.B. Walters, ed. (Ann Arbor Press, Ann Arbor, MI) 1981.

Keith, L.H., D.B. Walters and J.M. Harless, "Analysis and Storage of Hazardous Environmental Chemicals for Toxicological Testing," in The Chemistry of Environmental Agents as Potential Health Hazards, J.M. McKinney, ed. (Ann Arbor Press, Ann Arbor, MI) 1981.

Walters, D.B., L.H. Keith, J.M. Harless and J.T. Ward, "Chemical Selection and Handling Aspects of Large-Scale Toxicological Testing: An Overview," in The Chemistry of Environmental Agents as Potential Health Hazards, J.M. McKinney, ed. (Ann Arbor Press, Ann Arbor, MI) 1981.

Harless, J.M., et al., RCRA and Laboratories, (American Chemical Society Press, Washington, D.C.) 1983.

Harless, J.M., "Chemical Waste Management in Academic Laboratories," The pHilter, 16, 1 (1983).

Harless, J.M., "Components in the Design of a Hazardous Chemicals Handling Facility," in Health and Safety for Toxicity Testing, D.B. Walters and C.W. Jameson, eds. (Butterworth Publishers, Boston) 1984.

Walters, D.B., J.M. Harless and R.S. Strickoff, "Chemical Containment: Criteria for Toxicity Testing Facilities," in Health and Safety for Toxicity Testing, D.B. Walters and C.W. Jameson, eds. (Butterworth Publishers, Boston) 1984.

Harless, J.M., "Environmental Risk Assessment for Real Estate Transactions," Michigan Real Property Review, 14, 81 (1987).

PAPERS PRESENTED

- Harless, J.M., "Preliminary Results of Evaluations of the Level I Environmental Assessment Methods at a Coal Gasification Facility," Environmental Assessment Steering Committee, U.S. Environmental Protection Agency, Research Triangle Park, NC, March 13, 1978.
- Harless, J.M., K.E. Baxter, L.H. Keith and D.B. Walters, "Design and Operation of a Hazardous Materials Laboratory," Division of Chemical Health and Safety, American Chemical Society Annual Meeting, Washington, D.C., September 9-14, 1979.
- Harless, J.M., and R.L. Trammell, "Preparation of Quality Assurance Standards for Priority Pollutant Analyses," Division of Environmental Chemistry, American Chemical Society Annual Meeting, New York, NY, August 24-27, 1981.
- Harless, J.M., "Design of a Hazardous Materials Laboratory, Part II," Division of Chemical Health and Safety, American Chemical Society Annual Meeting, New York, NY, August 24-27, 1981.
- Harless, J.M., and R.L. Trammell, "A Quality Assurance Program for Preparation of Priority Pollutant Analytical Standards," Division of Analytical Chemistry, American Chemical Society Annual Meeting, New York, NY, August 24-27, 1981.
- Harless, J.M., "Design Considerations for a Toxic Chemicals Handling Facility," Division of Chemical Health and Safety, American Chemical Society Annual Meeting, Las Vegas, NV, March 28-31, 1982.
- Harless, J.M., and A.W. Nichols, "Preparation of Quality Assurance Standards for Hazardous Waste Analyses, Part I," Division of Environmental Chemistry, American Chemical Society Annual Meeting, Las Vegas, NV, March 28-31, 1982.
- Harless, J.M., and A.W. Nichols, "Preparation of Quality Assurance Standards for Hazardous Waste Analyses, Part II," Division of Environmental Chemistry, American Chemical Society Annual Meeting, Las Vegas, NV, March 28-31, 1982.
- Harless, J.M., "A Laboratory Safety Program for Handling Hazardous Environmental Samples," Division of Chemical Health and Safety, American Chemical Society Annual Meeting, Kansas City, MO, September 13-17, 1982.
- Harless, J.M., et. al., "Design and Operation of an Automated Glove Permeation Testing System," American Industrial Hygiene Association Annual Conference, Philadelphia, PA, May 12, 1983.
- Harless, J.M., et. al., "Chemical Structure/Glove Permeation Relationships Developed from the NTP Glove Permeation Program," American Industrial Hygiene Association Annual Conference, Philadelphia, PA, May 12, 1983.
- Harless, J.M., "Hazard and Risk Assessment for Handling Toxic Chemicals," Division of Chemical Health and Safety, American Chemical Society Annual Meeting, St. Louis, MO, April 8-13, 1984.
- Harless, J.M., "Storage and Shipment of Hazardous Materials," Division of Chemical Health and Safety, American Chemical Society Annual Meeting, St. Louis, MO, April 8-13, 1984.
- Harless, J.M., "A Detailed Regulatory Overview of RCRA," Michigan Industrial Hazardous Waste Conference, Detroit, MI, May 13-15, 1985.

Harless, J.M., "Impacts of Recent RCRA Changes on Hazardous Waste Generators," Michigan Industrial Hazardous Waste Conference, Detroit, MI, May 13-15, 1985.

Harless, J.M., "Local Government Agency Interactions with Hazardous Waste Generators," Hazardous Waste Issues for Local Government Officials Conference, Ann Arbor, MI, June 27, 1985.

Harless, J.M., "Chemical and Physical Analysis Requirements Under RCRA," Hazardous Waste Management - Realities and Remedies Symposium, American Chemical Society Annual Meeting, Chicago, IL, September 8-13, 1985.

Harless, J.M., "RCRA and CERCLA: Requirements, Realities and Society," Department of Engineering, Central Michigan University, October 21, 1985.

Harless, J.M., "Management of Hazardous Wastes in Industrial Research Laboratories," Ford Motor Company, Scientific Research Laboratories, Dearborn, MI, January 15, 1987.

Harless, J.M., "Environmental Audits for Hazardous Waste Management," Forging Industry Association Hazardous Waste Seminar, Chicago, IL, February 25, 1987.

Harless, J.M., "Sewage Disposal of Chemical Wastes - The Consultant's Liabilities," ACS Task Force on RCRA Symposium, American Chemical Society Annual Meeting, New Orleans, LA, August 30 - September 4, 1987.

Harless, J.M., "Hazard Determination for Hazard Communication," Symposium on Hazard Communication, American Chemical Society Midwest Regional Meeting, Wichita, KS, November 6, 1987.

Harless, J.M., and E.A. Cieply, "Labpacking vs. Co-Mingling of Hazardous Wastes," Third Chemical Congress of North America, Toronto, Canada, June 5 - 10, 1988.

Harless, J.M., and E.A. Cieply, "Management of Academic Laboratory Wastes - Tips from a Transporter," Third Chemical Congress of North America, Toronto, Canada, June 5 - 10, 1988.

Harless, J.M., "Hazardous Waste Regulations Compliance Audits", GenSem 1988, Liquid Industrial Controls Association, Dearborn, Michigan, September 8, 1988.

MISCELLANEOUS PRESENTATIONS

Harless, J.M., "Computerized Management of Chemical Hazard Information," Laboratory Safety Short Course, American Chemical Society, Houston, TX, April 23, 1981.

Harless, J.M., D.B. Walters, C.W. Jameson and W.B. Beranek, "Chemical Health Concerns," Health Fields, NBC Television, New York, NY, November, 1981.

Harless, J.M., "Inside Environmental Consulting," Inside the Environment, WCBN, Ann Arbor, MI, September 14, 1984.

Harless, J.M., "Industrial Hygienists as Consultants," School of Public Health, The University of Michigan, October 6, 1985.

Harless, J.M., "Environmental Risk Assessment for Real Estate Transactions," Commercial Lending Officer Seminar, Michigan National Bank Corporation, Troy, Michigan April 8, 1988.

Harless, J.M., "Environmental Affairs in Business Affairs," Propeller Club of Detroit, Wyandotte, Michigan, September 13, 1988.

Harless, J.M., "Environmental Risk Assessment for Real Estate Transactions," Robert A. Morris Banking Association, Grand Rapids, Michigan, October 27, 1988.

PATENTS

Harless, J.M., et al., "Permeation Testing Apparatus," U.S. Patent No. 4,468,951, September 4, 1984.

DAVID A. FELINSKI

EDUCATION

M.S., Physiology, Eastern Michigan University, 1982
B.S., Psychology, Eastern Michigan University, 1978

EXPERIENCE

* Summary

Senior Scientist, Techna Corporation	
Industrial Hygienist, Techna Corporation	1987 - Date
Sales Representative, Richards Medical Company	1984 - 1987
Endoscopy Technician, St. Joseph Mercy Hospital	1982 - 1984
Emergency Room Technician, St. Joseph Mercy Hospital	1975 - 1982
Instructor, Eastern Michigan University	1979 - 1982

* Techna Corporation, Ann Arbor, Michigan

Primary responsibilities as Senior Scientist and Manager of the Chemical Management Section of Techna include design and management of safety and health activities, management of "ChemReg", Techna's comprehensive chemical regulatory compliance database and hazardous chemical management projects. Specific project activities include preparation of contingency plans, production of HazCom and RCRA videotape training programs, asbestos monitoring and abatement management, preparation of facility combined SPCC/PIPP/RCRA contingency plans, and SARA Title III compliance services. Other technical responsibilities include direct management of environmental assessments, environmental compliance and risk assessment audits, and hazardous waste management programs. Activities have included development of hazard communication programs, hazardous waste disposal, preparation of air and wastewater discharge permits, effluent monitoring, asbestos surveys, urea formaldehyde foam and radioactivity surveys, and in-plant chemical inventory development and management.

* Richards Medical Company, Memphis, Tennessee

Responsibilities included direct sales of orthopaedic implants and equipment, and operating room support for the use of that equipment. These responsibilities involved over 60 surgeons in ten major Michigan hospitals. Other activities included the design and development of training and marketing aids for Richard's products.

*** St. Joseph Mercy Hospital, Ann Arbor, Michigan**

Emergency Room Technician responsibilities included triage and initial clinical assessment/screening of incoming patients. Typical activities included CPR, application of splints and casts, EKG tests, minor suturing, and IV therapy.

Endoscopy Technician responsibilities involved assisting physicians with all endoscopic diagnostic and therapeutic procedures. Activities included patient counseling, administering of sedative drugs, and patient monitoring during procedures.

*** Eastern Michigan University, Ypsilanti, Michigan**

Taught graduate and undergraduate courses in anatomy, human physiology, anatomy and physiology for nurses, and transmission electron microscopy. Activities involved developing and presenting lectures, preparing and administering oral and written examinations, and developing and instructing laboratory programs. Also authored and illustrated a 150 page laboratory instruction manual for human dissection.

PUBLICATIONS

Felinski, D.A., and Harless, J.M. "University Compliance Requirements Under SARA/Title III, Community Right-to-Know Regulations" Amer. Chem. Soc. Network News Vol. 2, No. 1

Felinski, D.A., and Burton, S. "Elementary and Secondary School Compliance Requirements Under Hazard Communication and SARA/Title III - Community Right-to Know Regulations" Amer. Chem. Soc. Chemunity '88, Vol. 9, No. 3

Felinski, D.A. "Laboratory Manual of Human Dissection" Burgess-Meredith, 1981

PRESENTATIONS

Felinski, D.A., "Computer Databases for Regulatory Compliance and Waste Management Activities", LICA GenSem, September 1988

SPECIAL ACTIVITIES

Member - Executive Subcommittee; Oakland County Local Emergency Planning Committee

Consultant - Hillsdale County Local Emergency Planning Committee

EDUCATION

M.S., Civil Engineering, State University of New York, In Progress
B.S., Civil Engineering, State University of New York, 1975

EXPERIENCE

* Summary

Section Leader, Techna Corporation	1988 - Date
Project Manager, Granger Construction Company	1985 - 1988
Project Resident Engineer, McNamee Porter and Seeley	1982 - 1985
Resident Engineer, McNamee Porter and Seeley	1977 - 1982

* Techna Corporation, Ann Arbor, Michigan

Primary responsibilities as Senior Project Engineer and Site Assessment Section Leader include design and management of hazard waste permit support programs and site investigation and remediation projects. Specific project activities include preparation of facility contingency plans, preparation of RCRA Part B permit applications, and development and implementation of RCRA Part A facility closure plans. Other technical responsibilities include environmental assessments, environmental compliance and risk assessment audits, and hazardous waste management programs. Activities have included development of Part B permit applications for automotive and chemical production plants, development of Part A closure plans for multiple container storage and UST sites, and management of numerous site investigation and risk assessment programs.

* Granger Construction Company, Lansing, Michigan

Served as Project Manager for construction of the Kent County (Michigan) Solid Waste Recovery Facility (refuse incineration/co-generation) and the G. Robert Cotton Correctional Facility. Responsibilities included negotiating and administering subcontracts, preparing cost estimates, coordinating design professionals, expediting/coordinating engineering design drawings, equipment and materials, and directing field supervisors.

* McNamee Porter and Seeley, Ann Arbor, Michigan

Activities as Project Resident Engineer involved on-site contract administration during construction of the wastewater treatment plant for the city of Lapeer, Michigan. Specific

responsibilities included on-site representation of design engineers, supervision of inspection and testing personnel, maintenance of construction records, and management and review of contractor performance. Also supervised the installation, testing and start-up of all architectural, structural, mechanical, electrical and instrumental systems and sub-systems.

Responsibilities as Resident Engineer included design and construction management for major plant expansions of the Three Rivers Filtration Plant in Fort Wayne, Indiana. Additions included pneumatic material conveying systems, chemical feed equipment and dual media high rate gravity filters. Other responsibilities and activities as Resident Engineer included design and management of sanitary sewer installations and construction of sewer system pump stations in Green Oak Township, Michigan.

CERTIFICATIONS

Registered Professional Engineer - Michigan #28225

Grade AT Water Works Operator Certificate - Indiana #803159

AFFILIATIONS

National Society of Professional Engineers

SARAH BURTON

EDUCATION

M.S., Chemistry, University of Michigan, 1986
B.A., Chemistry, Russian Studies, Randolph-Macon Woman's College, 1985
Safety At Hazardous Materials Sites - NWWA,(29 CFR 1910, 120 (2) (e))

EXPERIENCE

* Summary

Chemist, Techna Corproation	1988 - Date
Chemistry/Math Teacher, Greenhills School	1986 - 1988
Instructor, University of Michigan	1985 - 1986
Research Assistant, Virginia Chemicals, Inc.	1984

* Techna Corporation, Ann Arbor, Michigan

Responsibilities as chemist in the Chemical Management Section of Techna include hazards evaluations and risk assessments, SARA, DOT, RCRA, and OSHA categorization on over three thousand hazardous chemicals for purposes of incorporation into ChemReg, Techna's chemical regulatory compliance database. Activities have included several asbestos/formaldehyde survey and risk assessments, contingecy plan development, in-plant chemical inventory development and management, environmental impairment risk assessments including soil and groundwater sampling, Underground Storage Tank investigations, and radioactivity surveys.

* Greenhills School, Ann Arbor, Michigan

Responsibilities as a chemistry and mathematics educator included standard teaching and preparation functions in chemistry, advanced chemistry, and algebra, as well as maintenance of laboratory equipment and chemical stockrooms. Activities included writing curriculums for new labs involving micro-technique.

* University of Michigan, Ann Arbor, Michigan

Responsibilities as a Chemistry Teaching Assistant included supervising general chemistry laboratories; leading recitation, discussion and problem-solving sessions; administering and grading written examinations.

* Virginia Chemicals, Portsmouth, Virginia

Responsibilities as a Research Assistant included developing new methods for quality control in the Analytical Research and Development Lab involving the use of capillary gas chromatography and atomic absorption spectrometry.

AFFILIATIONS

American Chemical Society
Phi Beta Kappa

PUBLICATIONS

Felinski, D.A., and Burton, S., "Elementary and Secondary School Compliance Requirements Under Hazard Communication and SARA/Title III - Community Right-To-Know Regulations"; A.C.S. Chemunity '88, Vol. 9, No. 3

PAPERS PRESENTED

Burton, S., "Isolation and Identification of Lectin Proteins in the Seeds of *Cersis canadensis*"; Tri-College Symposium, Lynchburg, Virginia, April 21, 1985.

Burton, S., "Transition to Math 7"; University of Michigan Math Education Conference, Ann Arbor, Michigan, February 6, 1988.

MARY C. ADAMS

EDUCATION

B.S., Engineering Science, University of Michigan School of Engineering, 1983
B.S., Zoology, University of Michigan, 1973

EXPERIENCE

- Summary

Environmental Engineer, Techna Corporation	1986 - Date
Environmental Engineer, Roy F. Weston, Inc.	1985 - 1986
Associate Environmental Engineer, Environmental Research Group, Inc.	1984 - 1985

- Techna Corporation, Ann Arbor, Michigan

Responsibilities as Environmental Engineer include design and implementation of site assessment programs at contaminated industrial and waste management facilities, environmental sampling, regulatory compliance programs, liaison with regulatory agencies, and environmental audits. Activities have included management of site assessment programs, design of remedial programs, and negotiations with regulatory agencies concerning site assessment and remedial action program requirements.

- Roy F. Weston, SPER Division, Romulus, Michigan

Performed environmental engineering, management, and safety services as a member of the Technical Assistance Team (TAT) for the USEPA Region V. Responsibilities included site assessment and site management activities at Superfund NPL sites and emergency response sites. Principal activities included design and implementation of site assessment programs, management of site activities including sampling and analysis, remedial actions, safety and health procedures, and subcontractor activities. Other activities included soil and water sampling, hazardous waste consolidation and sampling, data interpretation, and reporting. Sites included PCB contamination areas, abandoned hazardous waste sites, chemical spills, and industrial drum piles.

- Environmental Research Group, Inc., Ann Arbor, Michigan

Performed a wide variety of environmental regulatory compliance services for industrial clients. Specific responsibilities included project development, implementation, and reporting as well as regulatory interpretations and liaison with regulatory agencies. Activities included preparation of RCRA permit applications, development of hazardous waste management and minimization programs, preparation of wastewater discharge permits, and management of NPDES effluent and RCRA groundwater monitoring programs. Other activities included sampling of soils, wastewater, groundwater, process streams, and point source air emissions as well as quality assurance monitoring of asbestos abatement activities.

- Ford Motor Company, Fuel Systems Engineering Laboratory, Dearborn, Michigan

Performed air and fuel flow tests on prototype and experimental carburetors to evaluate fuel efficiency variables. Other activities included evaluation of test data and preparation of test reports for submission to the USEPA.

APPENDIX E
HAZARDOUS SUBSTANCE INFORMATION FORMS

Hazardous Substance Information Form

COMMON NAME: Trichloroethylene ^{Other} CHEMICAL NAME: Ethylene trichloride, Triclene

I. PHYSICAL/CHEMICAL PROPERTIES

	Natural physical state: Gas _____ Liquid <input checked="" type="checkbox"/> Solid _____	SOURCE
(at ambient temps of 20°C-25°C)		NIOSH, SAX
Molecular weight	131	g/g-mole NIOSH
Density ^a	1.4649	g/ml SAX
Specific gravity ^a	e	°P/°C
Solubility: water	0.1% e 25	°P/°C NIOSH
Solubility ^b :	e	°P/°C
Boiling point	188	°P/°C NIOSH
Melting point	-123	°P/°C NIOSH
Vapor pressure	100 mmHg e 32	°P/°C SAX
Vapor density	e	°P/°C
Flash point	8.96	°P/°C SAX
(open cup _____; closed cup _____)		
Other: <u>sweet odor like Chloroform</u>		

II. HAZARDOUS CHARACTERISTICS

A. TOXICOLOGICAL HAZARD	HAZARD?	CONCENTRATIONS (PEL, TLV, other)	SOURCE
Inhalation	<u>Yes</u> No	50 ppm TLV	ACGIH
Ingestion	<u>Yes</u> No	4920 mg/kg LD50 rat	SAX
Skin/eye absorption	Yes No		
Skin/eye contact	<u>Yes</u> No		
Carcinogenic	<u>Yes</u> No		
Teratogenic	Yes No		
Mutagenic	<u>Yes</u> No		
Aquatic	Yes No		
Other: _____	Yes No		

B. TOXICOLOGICAL HAZARD	HAZARD?	CONCENTRATIONS	SOURCE
Combustibility	Yes No		
Toxic byproduct(s): <u>Chlorine</u>	<u>Yes</u> No		SAX
Flammability	<u>Yes</u> No		
LFL		12.5%	SAX
UPL		90.0%	
Explosivity	<u>Yes</u> No		
LEL		11%	NIOSH
UEL		41%	

^aOnly one is necessary.

^bFor organic compounds, recovery of spilled material by solvent extraction may require solubility data.

000001

CONTINUED ON BACK

Hazardous Substance Information Form

COMMON NAME: Aluminum Salts CHEMICAL NAME: _____

I. PHYSICAL/CHEMICAL PROPERTIES

		SOURCE
Natural physical state: Gas _____ Liquid _____ Solid <u>X</u>		
(at ambient temps of 20°C-25°C)		
Molecular weight	<u>N/A</u> g/g-mole	
Density ^a	<u>N/A</u> g/ml	
Specific gravity ^a	<u>N/A</u> @ _____ °F/°C	
Solubility: water	<u>Variable</u> @ _____ °F/°C	
Solubility ^b : _____	<u> </u> @ _____ °F/°C	
Boiling point	<u>N/A</u> °F/°C	
Melting point	<u>N/A</u> °F/°C	
Vapor pressure	<u>mmHg</u> @ _____ °F/°C	
Vapor density	<u> </u> @ _____ °F/°C	
Flash point	<u>N/A</u> °F/°C	
(open cup _____; closed cup _____)		
Other: _____		

II. HAZARDOUS CHARACTERISTICS

A. TOXICOLOGICAL HAZARD	HAZARD?	CONCENTRATIONS (PEL, TLV, other)	SOURCE
Inhalation	<u>Yes</u> No	<u>2 mg/m³</u> TLV	
Ingestion	<u>Yes</u> No		
Skin/eye absorption	Yes No		
Skin/eye contact	<u>Yes</u> No		
Carcinogenic	Yes No		
Teratogenic	Yes No		
Mutagenic	Yes No		
Aquatic	Yes No		
Other: _____	Yes No		

B. TOXICOLOGICAL HAZARD	HAZARD?	CONCENTRATIONS	SOURCE
Combustibility	Yes <u>No</u>		
Toxic byproduct(s): _____	Yes <u>No</u>		

Flammability	Yes <u>No</u>		
LPL			
UPL			
Explosivity	Yes <u>No</u>		
LEL			
UEL			

^aOnly one is necessary.

^bFor organic compounds, recovery of spilled material by solvent extraction may require solubility data.

Hazardous Substance Information Form

COMMON NAME: Chromium Compounds CHEMICAL NAME: _____

I. PHYSICAL/CHEMICAL PROPERTIES

			SOURCE
Natural physical state: Gas _____ Liquid <u>X</u> Solid <u>X</u>			
(at ambient temps of 20°C-25°C)			
Molecular weight	<u>N/A</u>	g/g-mole	
Density ^a	<u>N/A</u>	g/ml	
Specific gravity ^a	<u>e</u>	°F/°C	
Solubility: water	<u>Variable</u>	°F/°C	
Solubility ^b : _____	<u>e</u>	°F/°C	
Boiling point		°F/°C	
Melting point		°F/°C	
Vapor pressure	<u>mmHg e</u>	°F/°C	
Vapor density	<u>e</u>	°F/°C	
Flash point	<u>NONE</u>	°F/°C	
(open cup _____; closed cup _____)			
Other: _____			

II. HAZARDOUS CHARACTERISTICS

A. TOXICOLOGICAL HAZARD	HAZARD?	CONCENTRATIONS (PEL, TLV, other)	SOURCE
Inhalation	<u>Yes</u> No	<u>0.05 mg/m³</u>	<u>ACGIH</u>
Ingestion	Yes No		
Skin/eye absorption	Yes No		
Skin/eye contact	<u>Yes</u> No		
Carcinogenic	<u>Yes</u> No		
Teratogenic	Yes No		
Mutagenic	Yes No		
Aquatic	Yes No		
Other: _____	Yes No		

B. TOXICOLOGICAL HAZARD	HAZARD?	CONCENTRATIONS	SOURCE
Combustibility	Yes <u>No</u>		
Toxic byproduct(s): _____	Yes <u>No</u>		
Flammability	Yes <u>No</u>		
LFL _____			
UPL _____			
Explosivity	Yes <u>No</u>		
LEL _____			
UEL _____			

^aOnly one is necessary.

^bFor organic compounds, recovery of spilled material by solvent extraction may require solubility data.

Hazardous Substance Information Form

COMMON NAME: Copper _{salts} CHEMICAL NAME: _____

I. PHYSICAL/CHEMICAL PROPERTIES

	SOURCE
Natural physical state: Gas _____ Liquid <u>X</u> Solid <u>X</u>	
(at ambient temps of 20°C-25°C)	
Molecular weight _____	N/A g/g-mole
Density ^a _____	N/A g/ml
Specific gravity ^a _____	N/A @ °F/°C
Solubility: water _____	Variable @ °F/°C
Solubility ^b : _____	@ °F/°C
Boiling point _____	N/A °F/°C
Melting point _____	N/A °F/°C
Vapor pressure _____	mmHg @ °F/°C
Vapor density _____	@ °F/°C
Flash point _____	@ °F/°C
(open cup _____; closed cup _____)	
Other: _____	

II. HAZARDOUS CHARACTERISTICS

A. TOXICOLOGICAL HAZARD		HAZARD?	CONCENTRATIONS	SOURCE
			(PEL, TLV, other)	
Inhalation	<u>Yes</u>	No	1 mg/m ³ TLV	
Ingestion	<u>Yes</u>	No	1210 mg/kg TDLo-rat	
Skin/eye absorption	Yes	No		
Skin/eye contact	<u>Yes</u>	No		
Carcinogenic	Yes	No		
Teratogenic	Yes	No		
Mutagenic	Yes	No		
Aquatic	Yes	No		
Other: _____	Yes	No		

B. TOXICOLOGICAL HAZARD		HAZARD?	CONCENTRATIONS	SOURCE
Combustibility	Yes	<u>No</u>		
Toxic byproduct(s): _____	Yes	<u>No</u>		
Flammability	Yes	<u>No</u>		
LFL				
UPL				
Explosivity	Yes	<u>No</u>		
LEL				
UEL				

^aOnly one is necessary.

^bFor organic compounds, recovery of spilled material by solvent extraction may require solubility data.

Hazardous Substance Information Form

COMMON NAME: Zinc salts CHEMICAL NAME: _____

I. PHYSICAL/CHEMICAL PROPERTIES

	SOURCE
Natural physical state: Gas _____ Liquid <u>X</u> Solid <u>X</u>	
(at ambient temps of 20°C-25°C)	
Molecular weight _____	N/A g/g-mole
Density ^a _____	N/A g/ml
Specific gravity ^a _____	N/A °F/°C
Solubility: water _____	N/A °F/°C
Solubility ^b : _____	°F/°C
Boiling point _____	N/A °F/°C
Melting point _____	N/A °F/°C
Vapor pressure _____	N/A mmHg °F/°C
Vapor density _____	°F/°C
Flash point _____	N/A °F/°C
(open cup _____; closed cup _____)	
Other: _____	

II. HAZARDOUS CHARACTERISTICS

A. TOXICOLOGICAL HAZARD	HAZARD?	CONCENTRATIONS (PEL, TLV, other)	SOURCE
Inhalation	<u>Yes</u> No	_____	_____
Ingestion	Yes No	_____	_____
Skin/eye absorption	Yes No	_____	_____
Skin/eye contact	<u>Yes</u> No	_____	_____
Carcinogenic	Yes No	_____	_____
Teratogenic	Yes No	_____	_____
Mutagenic	Yes No	_____	_____
Aquatic	Yes No	_____	_____
Other: _____	Yes No	_____	_____

B. TOXICOLOGICAL HAZARD	HAZARD?	CONCENTRATIONS	SOURCE
Combustibility	Yes <u>No</u>	_____	_____
Toxic byproduct(s): _____	Yes <u>No</u>	_____	_____
_____		_____	_____
Flammability	Yes <u>No</u>	_____	_____
LFL		_____	_____
UPL		_____	_____
Explosivity	Yes <u>No</u>	_____	_____
LEL		_____	_____
UEL		_____	_____

^aOnly one is necessary.

^bFor organic compounds, recovery of spilled material by solvent extraction may require solubility data.